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JOURNAL of the AMERICAN WELDING SOCIETY

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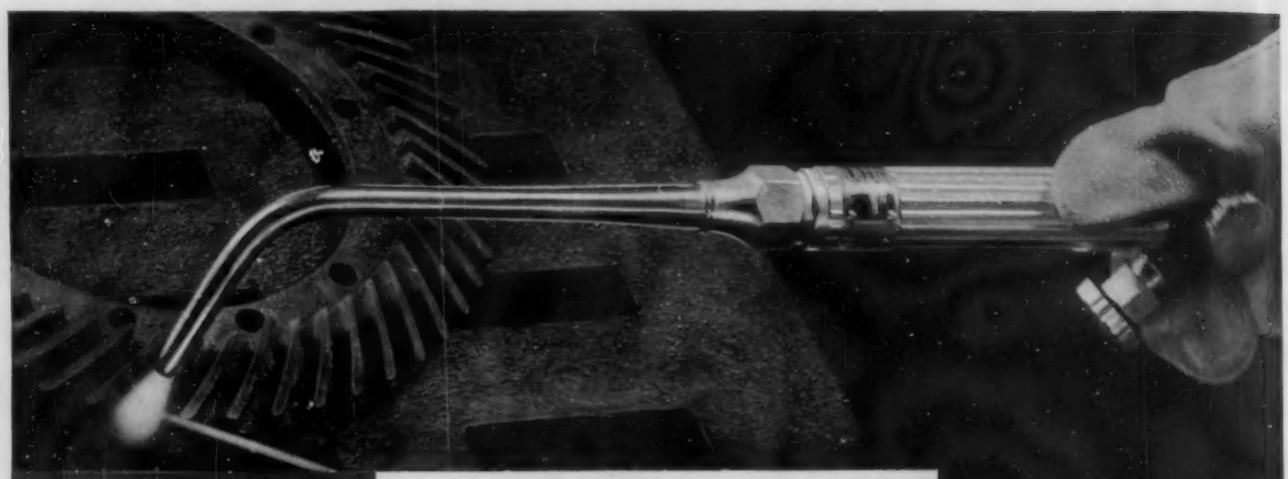
FOR THE ADVANCEMENT OF THE SCIENCE AND ART OF WELDING



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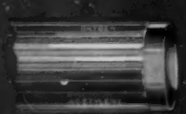

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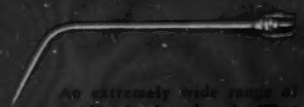

An extremely wide range of welding heads makes the W-17 unequalled for all-around work. Chromium plating, an exclusive Oxweld feature, prevents the adhesion of oxides and increases the life of the tips at least seventy-five per cent.

FOR PERFORMANCE AND DEPENDABILITY —Oxweld

OXWELD blowpipes fifteen years old—and even older—are still in daily use. These veterans of miles of welding—some of them almost as old as the welding industry itself—indicate with conclusiveness the long life of Oxweld Apparatus.

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JOURNAL of the AMERICAN WELDING SOCIETY

Issued Monthly

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1934

WM. SPRARAGEN
Editor

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SOCIETY AND RELATED ACTIVITIES

Officers Elected at 1934 Annual Meeting

President: D. S. Jacobus, The Babcock & Wilcox Co., New York.

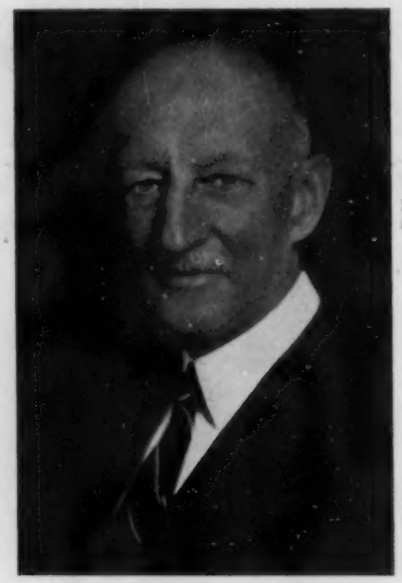
Senior Vice-President: J. J. Crowe, Air Reduction Sales Co., Jersey City, N. J.

Divisional Vice-Presidents: New York & New England Division—A. G. Leake, Leake & Nelson, Inc., Bridgeport, Conn. Middle Eastern Division—W. W. Reddie, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa. Middle Western Division—C. L. Eksergian, Budd Wheel Company, Detroit, Michigan.

Directors at Large: A. M. Candy, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.; J. H. Deppeler, Metal & Thermit Corp., New York, N. Y.; A. E. Gaynor, J. A. Roebling Sons Company, New York, N. Y.; O. E. Hovey, American Bridge Company, New York, N. Y.; L. S. Moisseiff, Consulting Engineer, New York, N. Y.

At the Board of Directors' meeting, Mr. C. A. McCune was reappointed Treasurer, and Miss M. M. Kelly, Secretary and Assistant Treasurer.

Dr. D. S. Jacobus



The AMERICAN WELDING SOCIETY is indeed fortunate in the recent election of Dr. D. S. Jacobus as its president. As far back as 1897, Dr. Jacobus experimented with the use of the oxyacetylene torch and an account of some of these experiments is published in the *Journal of the Franklin Institute*, March 12, 1897. The title of the lecture was "Artificial Light: Modern Methods Compared—Electric, Incandescent Welsbach, Acetylene." In these experiments, Dr. Jacobus used an oxyhydrogen torch, but operated with acetylene instead of hydrogen. These experiments also included the cutting of thin steel. These early experiments at the time that carbide was first made, proved highly interesting as well as entertaining and demonstrated the high heat value of the oxyacetylene flame in a number of ways. For a number of years Dr. Jacobus reported on all the acetylene generating machines that came to the New York Board of Fire Underwriters for approval. Dr. Jacobus worked on tests to determine the feasibility of enriching compressed city gas with acetylene for railroad car lighting and the apparatus in which he generated the acetylene under pressure finally exploded, blowing down a long partition in the building and making a hole about 10 ft. in diameter through the roof. Luckily no one was hurt.

Dr. Jacobus was born in Ridgefield, N. J., January 20, 1862. He married Miss Laura Dinkel of Jersey City on April 5, 1899, and has two children. Dr. Jacobus graduated from Stevens Institute of Technology in 1884. He received a degree of Doctor of Engineering in the same university in 1906. He taught experimental mechanics and engineering of physics at Stevens Institute from 1884 to 1906 and the latter year he joined the Babcock & Wilcox Company as advisory engineer and is now head of the engineering department.

He has written many papers and is considered one of the world's authorities on steam engineering. He is a member of many societies, including the American Society of Mechanical Engineers, Society of Naval Architects and Marine Engineers, American Institute of Mining Engineers, American Mathematical Society, Society for the Promotion of Engineering Education, American Institute of Electrical Engineers, American Society for Refrigerating Engineers, Franklin Institute, The Holland Society of New York, American Association for the Advancement of Science, as well as the AMERICAN WELDING SOCIETY.

His presidency of the AMERICAN WELDING SOCIETY is his third service in this capacity. He served as president of the American Society of Refrigerating Engineers from 1906 to 1907, and president of the American Society of Mechanical Engineers from 1916–1917. While president of the A. S. M. E. he was one of the organizers of a series of Military Lectures on Preparedness, and later on became a member of the Military Engineering Committee organized to arouse engineers to the need of preparedness and to instruct them in military tactics. The movement was a highly successful one.

He was a member of the Organization Committee for the Industrial Census which was obtained as a war time measure for the purpose of assisting the Naval Consulting Board.

Members of the AMERICAN WELDING SOCIETY know Dr. Jacobus best in connection with his work as chairman of the Executive Committee of the Boiler Code Committee. Dr. Jacobus has followed the developments of welding with keen interest. From the outset he saw the possibilities of welding and in his capacity with the Boiler Code Committee, gradually brought about the more liberalization of the rules dealing with the welding of pressure vessels, keeping in mind, however, suitable safety provision so that at the present time there is no limitation on the use of welding for any thickness or size of pressure vessels providing the welding is properly done and meets required tests. Dr. Jacobus was instrumental in bringing about close cooperation and harmony with the AMERICAN WELDING SOCIETY and the American Society of Mechanical Engineers.

This cooperation results in the recognition of the AMERICAN WELDING SOCIETY as the foremost authority on all welding matters. Under his leadership the AMERICAN WELDING SOCIETY may expect the bringing together of the Sections of the Society into close cooperation with national headquarters and continued growth and advancement of the Society itself. Dr. Jacobus is well known to all of our members, having served on the American Bureau of Welding since its inception. He has also been a member of the Board of Directors for several years, as well as a member of the Executive Committee of the Society.

Our Senior Vice-President

John J. Crowe, senior Vice-President of the Society, was reelected in the same capacity. Although well known to the Society, many of our new members will be interested in a brief biography. John was born on January 3, 1886. He was educated in Washington, D. C., having attended public schools, high school and George Washington University. He also taught at the University and became connected with the Bureau of Standards as an apprentice in heat and pyrometry advancing to associate physicist in metallurgy. From 1915–1917 he was connected with the Boston Navy Yard as a physical metallurgist in the development of anchor chain and other work with the metallurgical and physical testing laboratory. From 1917–1924 he was in charge of Metallurgical and Physical Testing Laboratory of the Philadelphia Navy Yard. For the last ten years he has been connected with the Air Reduction Company as engineer in charge of Apparatus Research & Development Department. He has served as Director of the AMERICAN WELDING SOCIETY for the past ten years and has been Senior Vice-President since 1933. He has also been director of the American Society for Metals and Chair-

man of their Philadelphia and New York chapters. He served as Director of Metallurgy at Temple University from 1921–1923. He is a member, also, of the American Institute of Mining & Metallurgical Engineers and Compressed Gas Manufacturers Association and the International Acetylene Association. Some of his papers are: "Economies through the Use of High Purity Oxygen," AMERICAN WELDING SOCIETY, 1925; "Location of AC_2 Point in Pure Iron," Bureau of Standards, 1912; "Observations on Ocean Temperatures in the Vicinity of Icebergs," Bureau of Standards, 1913, etc.; "Finishing Temperatures of Rails," Bureau of Standards; "Effect of Tip Sizes and Pressures upon Economy of Cutting," International Acetylene Association, 1928. He also has a number of patents on oxyacetylene equipment. He has served on numerous committees of the AMERICAN WELDING SOCIETY and is one of its most faithful workers.

Power Supply for Welding

The AMERICAN WELDING SOCIETY has an active committee under the chairmanship of Mr. H. A. Woofter to render assistance to power companies in supplying information as to equipment that would be necessary for operating large welders.

The developments in welding and particularly the resistance welding field have been rapid. These developments call for more and more power. Not only are larger cross sections welded than ever before, but they are done in a fraction of the time formerly found necessary. With an appropriate understanding of the welding requirements it is feasible and practicable to supply the necessary power to operate these welders.

Moreover, the tendency in welding certain metals and in doing certain jobs is to use carefully controlled power where the number of cycles at which the current is on can be accurately controlled. This control results in better welds and with proper understanding makes possible synchronous operation of several machines. The committee has rendered assistance to several important power companies. Inquiries may be addressed to the AMERICAN WELDING SOCIETY.

Annual Meeting

The Annual Meeting of the AMERICAN WELDING SOCIETY was held in New York on April 26th. The meeting opened with a business meeting at which the President summarized the activities of the Society during the year. A copy of the President's Annual Report is printed elsewhere in this Journal. A number of committee chairmen commented briefly on the work of their committees and indicated future activities. The afternoon was devoted to a meeting of the American Bureau of Welding and a meeting of the Structural Steel Welding Committee. Professor C. A. Adams, Director of the Bureau, summarized the progress of the Bureau during the year and stated that thirteen reports were published. The Bureau activities were pretty largely given over to the Fundamental Research Committee, which had some forty-nine investigations under way at university and governmental laboratories, and the work of the Structural Steel Welding Committee.

Mr. L. S. Moisseiff, Chairman of the Structural Steel Welding Committee, reported that arrangements had been made with Lehigh University for conducting a series of investigations on welded shelf angles and other welded connections. Professor Lyse and his associates briefly outlined the purposes of the investigation and with the aid of slides summarized the progress made to date. Arrangements were made by the committee to continue investigations at Lehigh University for another year. It is expected that a complete progress report will be presented at the Fall Meeting of the Society which will be held in New York during the first week of October.

Officers of the American Bureau of Welding

The following Officers of the Bureau were elected to serve for another year:

Director, C. A. Adams
1st Vice-Director, H. M. Hobart
2nd Vice-Director, J. H. Critchett
Secretary, W. Spraragen

At the meeting of the Bureau the Director appointed the following members to serve on the Executive Committee in addition to the elected Officers:

C. A. Adams, *Chairman*	H. M. Hobart
W. Spraragen, *Secretary*	D. S. Jacobus
J. H. Critchett	C. H. Jennings
J. J. Crowe	L. S. Moisseiff
J. H. Deppeler	E. M. T. Ryder

Philadelphia Section to Give Course of Lectures

At the Board of Directors' meeting, Mr. R. D. Thomas, representative of the Philadelphia Section, stated that the Section had under consideration possibility of a series of lectures of interest to men whose contact with welding is from the engineering and executive standpoint. The course is to be free to members of the AMERICAN WELDING SOCIETY. Additional details will be given in a later issue of the Journal.

Executive Committee of the Society

The following members were appointed to serve on the Executive Committee for the coming year:

C. W. Bryan, Jr.	H. S. Smith
E. H. Ewertz	E Vom Steeg
F. M. Farmer	J. J. Crowe
A. Weymouth	C. A. McCune
H. L. Whitney	M. M. Kelly
J. H. Deppeler	W. Spraragen
R. S. Donald	D. S. Jacobus, *Chairman*

1934 Meeting and Exposition

At the Annual Meeting, Mr. C. A. McCune, Chairman of the Convention Committee, reported that the Fall Meeting of the Society would be held in New York during the first week of October in connection with the National Metal Exposition with which the Society is cooperating. The Hotel New Yorker was selected as headquarters during the Fall Meeting because of its convenience to the Port of Authority Building where the convention will be held and special facilities placed at the disposal by the hotel.

The New York Section officers are cooperating with the Convention Committee to make this particular Fall Meeting an outstanding success. A special Dinner Committee appointed under the chairmanship of Mr. A. F. Keogh is proposing to hold a stag dinner which will be of special interest to the members of the Society. The Meetings and Papers Committee, under the chairmanship of Mr. J. B. Tinnon, have plans under way for an unusually attractive technical program. This will be supplemented by an inspection trip which will be arranged in cooperation with the New York Section.

Code for Pressure Piping

Considerable progress has been made in cooperation with the American Society of Mechanical Engineers in the development of a code for pressure piping. The portion relating to welding is under the particular supervision of a committee of the AMERICAN WELDING SOCIETY, under the chairmanship of Mr. T. W. Greene. Copies of draft of this Code are available in the Society office at twenty-five cents.

Construction of a Hortonsphere

The Chicago Bridge and Iron Works has recently advised this office that a 54-ft. x $1^{3}/_{16}$-in. sphere would soon be constructed for the Central Hudson Gas and Electric Company at Newburgh, N. Y., by welding. Members of the Boiler Code Committee are arranging for an inspection trip. Members of the Society interested should communicate with this office.

Annual Report of President Year Ending March 31, 1934

To Members of the AMERICAN WELDING SOCIETY:

It is gratifying to be able to present a report which shows that a financial loss of $1747 in the previous year has been transformed into a profit of $887, and that for the first time in three years the Society is able to report a net gain in its membership.

Finances

Regarding Income.—Membership Dues—receipts for the fiscal year increased 5½%. Journal advertising—receipts for the fiscal year decreased 4%. Subscriptions—receipts for the fiscal year decreased 2%. Miscellaneous income—receipts for the fiscal year increased 42%.

In aggregate, gross income shows a general increase of 3%, as compared with a decrease of 22% in the previous fiscal year.

Regarding Expense.—A comparison of the expense items indicates that the management has continued to make every effort to reduce overhead charges—and has been successful.

Journal costs decreased 10%. Salaries and other general administrative expenses decreased 8⅓%. In aggregate, expense shows a decrease of 9%.

Membership

As a result of the membership drive started last October, the Membership Committee reports that up to April 10th, 149 new members were secured with a net profit to the Society of $1021. This drive stemmed the loss in membership so that the Society is able to report a net gain of 91 members for the year.

The committee has sponsored a reclassification in membership grades with a view to simplifying the membership structure, which is now receiving consideration by the Sections.

The activities of the committee coupled with the efforts of the office staff, have brought about a decided improvement in the payment of dues of old members, for example, the percentage of delinquency less than six months, at the end of the fiscal year in 1933, was 14%, as compared with 9% in 1934.

Detail reports covering the above two activities, will be presented by the Chairmen of the Finance and Membership Committees.

Sections

All of our Sections with the exception of two, have been active during the past year. Meetings have been held regularly by them, and in most cases the Sections have reported exceptionally fine joint sessions with other technical associations. The Sections on the West Coast are considering the preparation and presentation of papers in the form of recommended practices for welding in various fields. The Boston Section should be congratulated for its cooperation in the intro-

(*Continued on page 5*)

SECTION ACTIVITIES

BOSTON

On April 20th the Boston Section held a meeting at Massachusetts Institute of Technology, with a varied program of motion picture films on oxyacetylene welding, demonstrations of gas and electric welding and testing of welded coupons supplied by those attending the meeting. The welding demonstrations were held in the Welding Laboratory at the Institute.

The Boston Section joined with six of the member societies of the Engineering Societies of Boston on April 27th, in a joint meeting sponsored by the Northeastern Section, American Society of Civil Engineers. Over 200 attended this meeting to hear short talks on the various features of the new light-weight streamline train, Burlington "Zephyr," of the Chicago, Burlington and Quincy Railroad. Mr. Ralph Budd, president of the Burlington Railroad, explained the purposes of having such a train, and then introduced Mr. Edward Budd of Edward Budd Mfg. Company, Philadelphia, who spoke on stainless steel and its application in the construction of the "Zephyr." Short talks were then given on the "Shot Welding of Stainless Steel," the new two-cycle, straight eight 600 H.P. diesel engine, and on the electrical wiring and control used in the train.

The Burlington Zephyr had been open for inspection that day at the South Station.

A joint meeting of this Section and the Boston Chapter, American Society of Metals, will be held Friday, May 4th, in room 5-330, Massachusetts Institute of Technology, at 7:30 P.M. The subject of this meeting will be "Boulder Dam." Five reels of film, supplied by The Babcock & Wilcox Company, showing activities at the Boulder Dam site will be shown. Views of fusion welding of the heavy steel plates and the X-ray examination of these welds are included in the film. Lantern slides about Boulder Dam generally, and on welding problems at the dam, will be shown. The speakers will be Mr. P. C. Idall and Mr. H. R. Karcher, both of The Babcock and Wilcox Company.

CHICAGO

A joint meeting with the Bridge and Structural Section of the Western Society of Engineers was held on April 23rd. Mr. L. K. Whitcomb of the Carnegie Steel Company spoke on "Welding and Its Application to Structural Steel." Mr. Whitcomb emphasized the fundamental details of design, stress distribution and suggestions for fields of structural welding. He illustrated his paper with lantern slides.

CLEVELAND

The regular monthly meeting of the Cleveland Section was held on April 11th. Mr. Lorn Campbell, President of the Harris Calorific Company spoke on "Reminiscences of an Oxy-Acetylene Welding Engineer." Mr. Campbell trained many welders during the war and he recently covered all the principal industrial countries of the world. He is the author of the first books published on welding.

DETROIT

The April meeting of the Detroit Section was held on the 19th. First on the program was the installation of officers. Following this a talk on "Wild Life" was presented by Paul W. Tara, Attorney-at-law, World traveler and hunter. Moving pictures of "Wild Life" were also presented by the speaker.

LOS ANGELES

The April meeting of the Los Angeles Section was held on the 19th. Mr. Frank Howard, Chairman of Committee on Welders' Qualifications, read a progress report sent by Mr. K. V. King, Chairman of the San Francisco Section, on the work done along this line by the San Francisco Section up to this time. Mr. Karl Strobel, President, Karl Strobel Corporation, spoke on "The Future of Welding."

NEW YORK

The last meeting of the 1933–1934 season was held on May 8th. Mr. Gilbert D. Fish, Consulting Engineer, spoke on "Design Features and the Application of Welding to the Construction and Repair of Steel Structures."

PITTSBURGH

The last regular meeting of the Pittsburgh Section until the early Fall was held on April 18th. Mr. Howard G. Marsh, Assistant Sales Manager, Carnegie Steel Company, Pittsburgh, gave a very interesting and enlightening talk on the use of rolled steel sections in the fabrication of welded products. He pointed out very clearly where marked savings in a finished piece of welded construction could be effected by the use of the proper size and shape of materials entering into the finished product. Over sixty members and friends attended the meeting.

SAN FRANCISCO

A most unusual meeting in the form of a lecture trip and outing was held on Saturday, April 28th by the San Francisco Section—a round trip across the Bay and the Golden Gate on a glass enclosed, double deck boat. The lower deck was used for music and dancing and from the upper deck there was ample opportunity to view the entire present construction work pertaining to the building of the World's two largest bridges, the Golden Gate Bridge and the San Francisco-Eastbay Bridge. The trip took around four hours and was enjoyed by every one. It was the consensus of opinion that it was an afternoon well spent both from the educational and entertainment view-points.

Annual Report

(*Continued from page 4*)

duction of an extension course in welding engineering at M. I. T. Arrangements of a similar nature are being considered by the Philadelphia Section. The activities of the Sections continue to be the greatest single aid in furthering the objectives of the Society.

Although no Sections have been organized during the year, our West Coast Divisional Vice-President reports that there are prospects of establishing Sections in Seattle, Salt Lake City and Denver.

Journal

The Journal of the Society, like other publications, has passed through a trying year. The total of 504 pages for the year 1933 compares favorably with 608 pages published in 1932. Its relatively small decrease in advertising and subscription compare favorably with information received from two other trade publications where the decrease for both advertising and subscription averaged four times that of our own Journal. Several new departments have been inaugurated. These have been designed to make the Journal of greater popular appeal. Many congratulatory letters have been received from prominent users of welding both here and abroad on the value of the Journal to them.

National Meetings

As a matter of economy, the technical sessions of the Annual Meeting last year were curtailed and several novel features in the way of lectures were introduced. This enabled the Society to save several hundred dollars and permitted special efforts in making the Fall Meeting a decided success.

As in previous years our 1933 Fall Meeting was held in conjunction with the National Metal Congress. The meeting took place in Detroit, October 2nd to 6th. Twenty-eight technical papers were presented on a wide variety of subjects. One of the features of the meeting was the large attendance at our technical sessions which ranged from several hundred to 400. The attendance at the industrial play held in conjunction with the International Acetylene Association was about 1600. Another feature of the meeting was inspections of the plants of the Kelsey Wheel Company and the Ford Motor Company.

Changes in By-Laws

During the year, amendments of Art. IV, Section 6, Nominations and Elections of Officers, and of Art. VII, Section 1, Committees, received majority approval of the membership, and are now in effect.

Consideration is being given to revision of Articles on Classification of Membership and Returns to Sections on Membership Dues. Every effort is being made to effect changes which will be to the best interests of the Society and at the same time enable the Sections to function properly. It is hoped before the close of this meeting that proposals offered by our special committee having this matter in hand will have received the approval of the Sections and the Board of Directors of the Society so that they may be submitted to the membership.

Society Committees

The following new projects have been initiated during the past year: Preparation of rules for Welding of Tanks Which Have Contained Combustible Liquids; Recommendations for the Welded Construction of Marine Buoys; Preparation of rules for the Welded Construction of Oil Storage Tanks above Ground (large-size tanks); Correlation of Present Code Requirements for Qualification of Welders; Formulation of Proper Procedure for Welding in the Construction of Railroad Rolling Stock and Appertenances Thereto. In the case of the two latter, which are in the *formative stage*, attention is being given to the selection of committee personnel. It is hoped within the coming year that the personnel of committee authorized to study welding of highway and railroad bridges, with a view to preparing specifications covering this work, will be completed. The work of the other committees during the year are briefly summarized below. More complete reports of the activities of these committees are available in the office of the Society for anyone interested.

Committee on Building Codes.—Much of this committee's time has been devoted to the formulation of Code 2 for Resistance Welding of Structural Steel in Building Construction and a revision of Code 1 for Fusion Welding and Gas Cutting in Building Construction. Both codes are nearly ready for final submittal for approval by the main committee and the Board of Directors of the Society. Information on structural welding and code data has been furnished to the Philadelphia City Planning Commission in the interest of code revision. The Boston Section has passed and submitted to the New England Building Officials' Conference a resolution recommending that our Building Code be incorporated in the Uniform Building Code under preparation for the states of New England. The American Institute of Steel Construction has recongized standards set up by our Society to the extent of recommending the use of welding in the construction of buildings at Yale University in accordance with these specifications. Digest of our building code has been incorporated in the Institute's new manual. Negotiations have been initiated with the A. S. A. for submittal to that association of our Code 1 looking toward the adoption of this code as an A. S. A. standard.

Committee on Welding Code for Pressure Piping.—In compliance with instructions received from the Board of Directors, the Chairman of this committee has been actively cooperating with the various committee Chairmen sponsoring the Pressure Piping Code. It was expected that the Pressure Piping Code in its entirety would be published by this time, but, due to criticism of Sections other than welding, final printing and release of the code have been delayed. It is expected that the code will be published this Summer. However copies of Tentative Section on Welding are available in the Society office. The Chairman of our committee has been cooperating in the way of editing.

Committee on Welding in Marine Construction.—Rules for the Construction of Fusion Welded Drums and Shells of Marine Boilers and Pressure Vessels prepared by a Sub-Committee on Marine Boilers, approved by the main committee and by the Board of Directors of the Society, have been accepted by the U. S. Department of Commerce Committee to coordinate marine boiler rules, and these form a part of tentative draft of proposed rules approved by that committee. Rules for Fusion Welding of Hulls and Hull Parts Prepared by Sub-Committee on Hull Construction, will be ready fairly soon for presentation to the Board of Directors.

Committee on Nomenclature, Definitions and Symbols.—Abbreviations and symbols for use in drawings of buildings, bridges and other framed structures, prepared by Sub-Committee on Structural Symbols, approved by the main committee and by the Executive Committee and Board of Directors of the Society, have been published in the Society Journal as tentative standards.* The revision of these symbols is now receiving consideration.

Revision of Marine and Resistance Welding Symbols, published in the 1929 Nomenclature Bulletin, is now receiving attention, and it is expected that the revised symbols will be presented in the near future. Consideration is being given to Arc and Gas Welding Symbols for Machinery Construction.

Committee on Use of Welded Steel Parts in the Construction of Machinery.—As the result of comments received at the last Annual Meeting, this committee undertook the revision of Code for Fusion Welding and Oxyacetylene Cutting in Machinery Construction. The revised code was presented at the December 12th Executive Committee meeting but in view of the fact that some of the Directors were unfamiliar with illustrations referred to in the code, it was decided to have these illustrations reproduced and furnished to the Directors, giving them an opportunity to study the code in its entirety. Comments received from the Directors have been forwarded to the Chairman of the committee. The committee is planning to hold a meeting on the morning of the Annual Meeting, and then submit its revised report to the Directors that evening.

Committee on Rules for Construction of Oil Storage Tanks.—Tentative recommendations of this committee covering procedure for welding of underground basement oil storage tanks, approved by the Executive Committee of the Society, have been furnished the Committee on Flammable Liquids of the National Board of Fire Underwriters. Preparation of standard welding procedure for the construction of oil storage tanks above ground has been undertaken and the committee has been enlarged to include repre-

*Nomenclature Bulletin with revised abbreviations and symbols is available in the Society office.

sentation from oil and tank manufacturing interests.

Legislative Committee.—During the year this committee has given attention to and acted on the following adverse legislative matters: Massachusetts Bill No. 1165 relating to licensing of welders and welding shops; New York State Bill No. 1755 dealing with licensing of welders; Cudahy, Wisconsin, U. S. Forest Service, revision of specifications so as to permit bids on welded road graders; Pennsylvania bill calling for enclosure of all locations where fusion welding is being performed.

Convention Committee.—Invitation has been accepted to participate in the 1934 National Metal Congress & Exposition to be held in New York the week of October 1st. The exposition will be in the Port of Authority Building, and the Hotel New Yorker has been selected for the Fall Meeting headquarters. The committee looks forward to a very successful meeting and exposition.

Committee on Reclassification of Membership and Returns to Sections on Membership Dues.—This committee offered recommendations for reclassifying the grades of membership and changing returns to Sections on membership dues which, having received the approval of the Directors, were referred to the Committee on Revision of By-Laws to be put in form for submittal to the membership. Further consideration is being given the effect of these proposals on our Sections.

American Bureau of Welding.—Efforts during the past year have been concentrated on two principal activities, namely, the further extension of the work of the Fundamental Research Committee, and a new program for the Structural Steel Welding Committee. During the year the following committees of the Bureau were discharged: Welded Rail Joint, Welding Wire Specifications and Standard Tests for Welds. Each of these committees completed its work and reports were published. During the year 13 reports have been issued by the American Bureau of Welding—most of them dealing with fundamental research work completed by university professors. Arrangements have been made with Lehigh University for the employment of a research fellow to conduct a series of investigations on welded connections.

Representation on Committees of Other Technical Societies

During the year cooperative relationship has been established with the American Railway Association by the appointment of C. A. Adams and J. J. Crowe on Sub-Committee on Fusion Welded Tank Car Tanks. The Society has continued to participate in the activities of the following organizations: A. S. M. E. Boiler Code Commitee; A. T. A. Way & Structures Committee No. 6 on Standard Specifications for Welding Rods; American Marine Standards Committee; A. S. A. Sectional Committees on Electrical Definitions, Electric Welding, Protection of Heads & Eyes of Industrial Workers, Electric Welding Dies and Electrode Holders, Sub-Committee No. 6 on Graphical Symbols for Drawings, Development of Ventilation Code, Safety Code for High Pressure Piping; A. S. T. M. Welding Wire Specifications Committee and Sub-Committees on Specifications for Steel for Fusion Welding and Wrought Copper and Copper Alloys; National Research Council; Executive Board of National Board of Boiler and Pressure Vessel Inspectors; Advisory Committee of Merchants Association on Revision of New York City Building Codes. Space does not permit giving a detailed account of all of these activites, although such accounts may be found in the files of the Society by anyone interested. Special recognition however is given to the work of our Conference Committee which cooperates with the A. S. M. E. Boiler Code Committee in formulating replies to inquiries received in connection with the application of the code rules to welded pressure vessels. During the year the committee has acted on three matters. Reports were prepared and, after approval by our executive body, these were transmitted to the Boiler Code Committee. Of special note also is the assistance rendered the A. T. A. and A. S. T. M. in the preparation of welding wire specifications, also that rendered the National Board of Boiler & Pressure Vessel Inspectors.

Recommendations

As a result of the year's activities, three recommendations present themselves:

1. That the membership drive so successfully carried on during the past year, resulting in a gain of 149 members and a profit of more than $1000, should be repeated at an early date, but on a somewhat larger scale, and with the full cooperation of the Board of Directors, Sections and member companies of the Society.

2. That new and additional services sponsored by the Sections of the Society should be inaugurated to attract new members and retain the old ones. For example, a welding engineering handbook, lecture courses and special endeavors in specific fields of application should be considered.

3. That the interest of the users of welding should be encouraged more and more in the administration of the affairs of the Society, through committee appointments, special assignments and in other ways.

Conclusions

The Society has weathered the storm, and we at this time should feel extremely fortunate in having secured as President a man who has the necessary time and experience to further increase the creditable accomplishments of the Society, and who, through his contemplated visits to our Sections, will bring about a closer relationship between the parent body and its widely scattered Sections. His success, in turn, will depend in a large measure upon the whole-hearted cooperation of every member of the Society working for the common good rather than for individual interest.

Severe Winter Gives Prominence to Welding Generators as Pipe Thawing Equipment

The unusual severity of the past winter, with its record snows and ice and subzero temperatures, has placed the electrical thawing of frozen pipes in the limelight, according to General Electric engineers. Arc-welding generators have been particularly useful for this service.

Although the practice of heating frozen pipes by passing an electric current through them is not new, it has taken a season when frozen water lines formed the rule, and not the exception, to bring the advantages of this thawing method into prominence. Such advantages are particularly apparent when the frozen pipes are underground or otherwise inaccessible.

Arc-welding generators, because of their special electrical characteristics, are extremely well suited to the work. High currents are required at relatively low voltage, and load resistance—the resistance of the length of pipe in the circuit—varies widely from job to job.

The process itself is simple. The leads from the generator are connected to the pipe or piping system so as to include the frozen section in the electric circuit. The heavy current warms the pipe and shortly melts the ice. The current required and the time necessary to effect thawing depend on the size and length of the pipe. For instance, it has been the experience of some users that 250 amp. will thaw a $^{1}/_{8}$-in. pipe 300 ft. long in from 3 to 10 min.—and again that a 3-in. pipe 100 ft. long will take nearly an hour with the current in the neighborhood of 500 amp. Voltages involved vary widely, usually between 10 and 50 volts being required. It is, therefore, readily understood why a welding generator, whose output voltage can be varied over a considerable range for several different current values, is so well adapted to thawing.

To obtain portability and mobility, a welding generator for pipe thawing is ordinarily mounted on a motor truck. A gas engine is the normal driving unit and the two machines can be either belted together or direct coupled.

Many welding companies owning truck-mounted welding generators have been able to render valuable emergency pipe thawing service.

1933 Bound Volume

The bound volumes of the Journal of the Society for the year 1933 are now available in imitation black leather covers. The volume includes a complete Subject and Authors' Index and contains a wealth of information on the latest developments in welding.

Members desiring copies should place their orders at once with the Secretary. Price to non-members $6.50. In order to save expense only a limited number of volumes were bound up. Orders of members will be filled first. Members, $5.00.

Widening the Circle of Industrial Recovery with the Electric Arc

By A. F. DAVIS

†Mr. Davis is Vice-President of The Lincoln Electric Company.

Brew Kettle "Stretched" to Double Capacity

"Stretching" a brew kettle so as to more than double its capacity proved a simple operation for the Cream City Boiler Company, Milwaukee, Wis. Arc welding provided the answer.

A local brewery had a fifty barrel per day capacity brew kettle which was insufficient for their requirements. An immediate increase of capacity was necessary to fulfill orders.

To accomplish this, the original spherical brew kettle was cut horizontally through the center. With the upper half elevated, four 3/16 x 66 x 84-in. sheets were inserted and lap welded over the exterior of the original kettle and butt welded to each other. In this manner the capacity of the brew kettle was increased to 107 barrels per day. It is literally a case of "stretching" this brew kettle to more than double its capacity. The work was completed in two days.

Figure 1 shows the welder making the lap weld of the new sheets to the spherical bottom of the brew kettle.

The Cream City Boiler Company specializes in the fabrication of all types of tanks, particularly those of alloy steel.

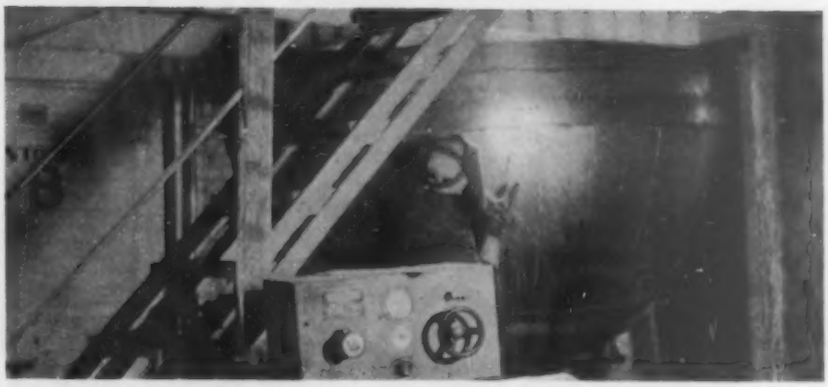


Fig. 1—Brew Kettle Enlarged to Twice Its Capacity in Two Days

Unique Monitor Frames Built for Ford's World's Fair Building

One-piece arc-welded monitor frames of unusual construction will take the place of the customary built-up trusses for the Ford Exposition Building at the Chicago Century of Progress.

The north wing of the building, which will house the Ford Industrial Exhibit, has three bays with monitor roof construction. In order to eliminate the maze of steel work presented by built-up monitor roof trusses, the architect, Albert Kahn, Inc., dispensed with trusses and used in their place continuous 21-in. I-beam monitor frames. These frames were formed by cutting triangular notches through one flange and the web of the beam, with the desired radius cut in the web above the other flange as shown in the upper part of Fig. 2. The beams were then bent to the proper shape, and, with a reinforcing strut on each side of the web, were welded with a 5/16-in. extra-heavy bead.

Close-up views of the welded joints are shown in Figs. 3 and 4. Fifty-eight monitor frames 40 ft. long were built by this method by the R. C. Mahon Company, Detroit, who were awarded the steel

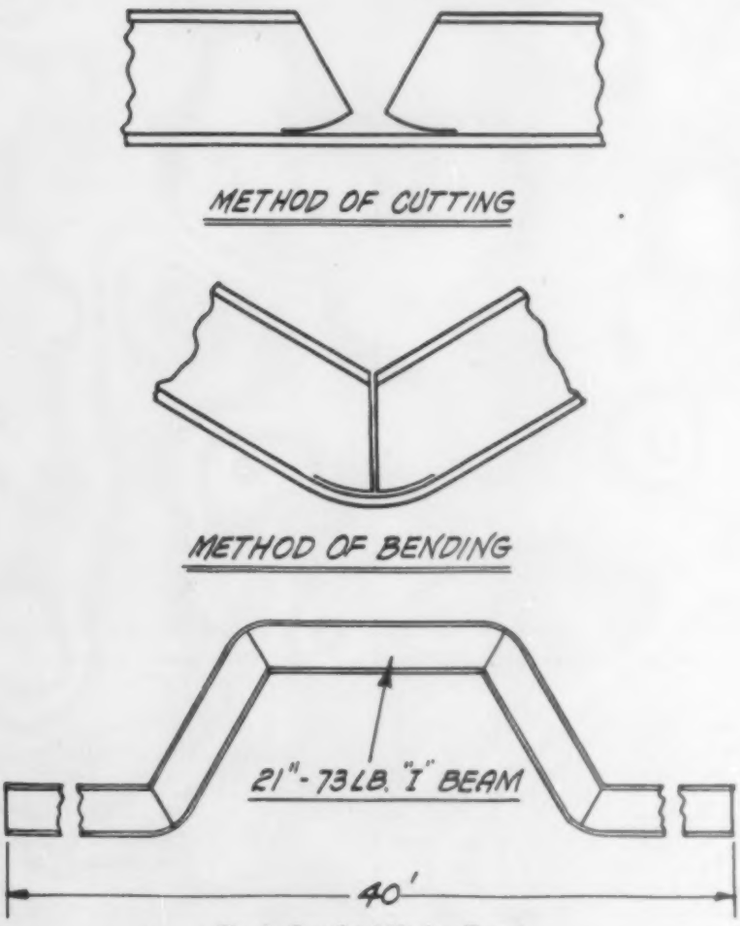


Fig. 2—Completed Monitor Frame

Fig. 3—Bent Portion of I-Beam Showing Welds

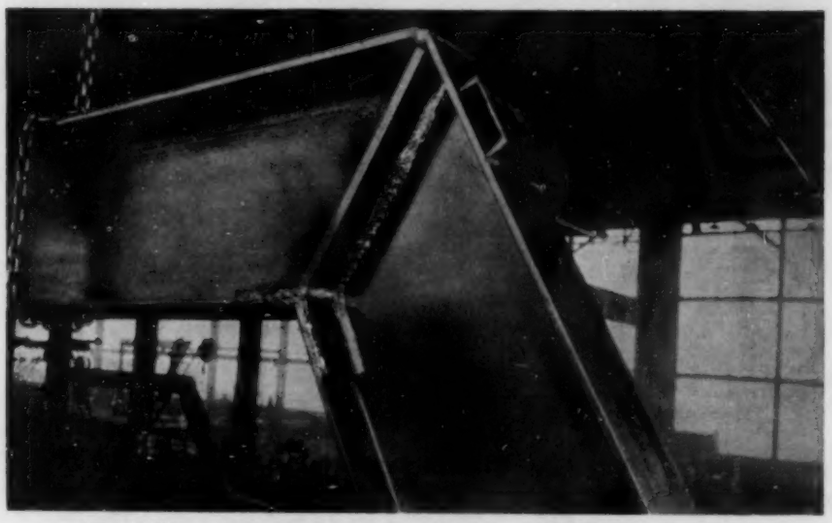


Fig. 4—Upper Section of Frame Showing Method of Joining Two Sections

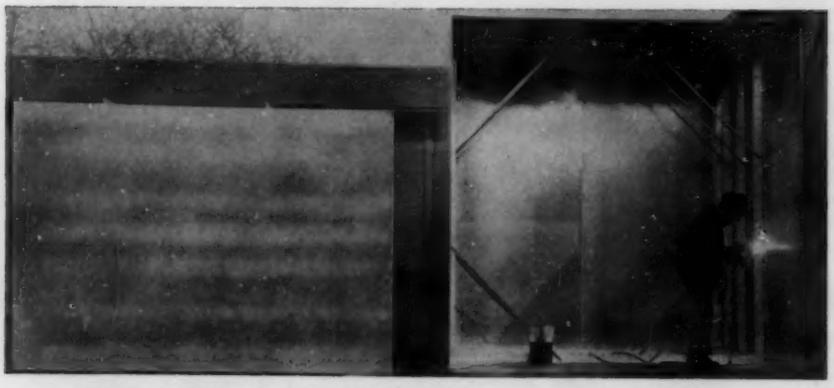


Fig. 5—Arc-Welded Aluminum Tanks Built for a Cleveland Chemical Plant

contract. Six small frames built of 12-in. I-beams were constructed in the same manner. All welds were made in position using $^{3}/_{8}$-in. covered electrodes.

The Ford Building is an excellent example of modern architecture and structural design. The building proper is 900 ft. long with a central rotunda 110 ft. high. The welded frames provided an important saving in steel and construction.

Many Orders Placed for Arc-Welded Aluminum Tanks

Improvements in arc welding technique on aluminum have resulted in a substantial increase in the number of orders placed recently for welded aluminum tanks and vessels.

Construction of two aluminum storage tanks for a chemical plant proved a simple matter for The Thornton Company, sheet metal works, of Cleveland. The electric arc made the job a simple one.

The tanks shown in Fig. 5 are 10 ft. square and 7 ft. high. The sheets are 3 S aluminum $^{3}/_{16}$ in. thick. Since there is to be an extremely small clearance between the tanks when installed, it was necessary to place all bracing on the inside. Three 3-in. angles of 17 S aluminum were welded to the sides as shown. Corner braces were then welded in place.

Butt welds, vertical welds and fillet welds were made in position, using the shielded-arc process with Aluminweld electrodes.

The tanks are completely enclosed with a manhole provided in the top in each case. Under test, no leaks were found in the welds.

Two round aluminum tanks of unusual construction have just been completed by The James Russell Boiler Works, Boston, Mass. (See Fig. 6.) These are only two out of some 12 or 14 aluminum tanks built recently by this company. The tanks were built for the storage of acetic acid.

The tanks are 8 ft. in diameter, 16 ft. long and have a capacity of 6000 gal. There is a steam coil in the bottom of each tank operating under a pressure of 10 to 15 lb.

The tanks themselves are made of $^{1}/_{4}$-in. aluminum plate. Previous to welding, tensile strengh tests of welds were made with results approximating those of the parent metal. All welds were ground flush and polished on completion so that there would be no irregularities in the parent metal.

Welding was done with $^{3}/_{16}$-in. and $^{5}/_{32}$-in. electrodes. Altogether there were more than 6000 ft. of welding involved. This company specializes in the welding of various alloy steels and non-ferrous metals.

Figure 7 shows another group of aluminum tanks recently fabricated by arc welding. This equipment is also for chemical plant usage. The three storage tanks are 6 ft. in diameter and 12 ft. high. These are built of $^{1}/_{4}$-in. aluminum with one circumferential seam.

At either end of the photograph are aluminum kettles and an agitator. These are of $^{1}/_{2}$- and $^{3}/_{8}$-in. metal.

World's Largest Capacity Barge Derrick Built by Arc Welding

An all-steel, arc-welded barge derrick, believed to be the largest in the world, has been completed by the Pennsylvania Shipyards of Beaumont, Texas. The barge is for use at the company's shipbuilding and repair docks and for emergency service in nearby rivers and on the Gulf Coast.

The barge has a capacity of approximately 100 tons on the heavy load line and, in addition to its use in repairs, it is adapted for salvage work, loading and unloading heavy parts and machinery, particularly where locomotive cranes are not available for the work.

The barge is of all-steel construction, electrically welded or riveted, with welding predominating. The hull is 106 ft. long,

has 44-ft. beam and 9-ft. 6-in. depth. It is equipped with ballast tanks to offset the weight of the loads handled.

A unique feature of this derrick barge is the tubular steel A-frame used in the construction of the derrick. Heavy steel plates were formed and welded to provide the three tubular members. These are 27 in. in diameter and 66 ft. long. Steps were welded to each of these uprights as shown in Fig. 8. Steel lattice work was built up by arc welding to form the reinforcement for the A-frame.

The boom is 100 ft. long, built entirely of welded steel lattice construction. It is 3 ft. 8 in. square through the largest section.

The barge itself was built largely by arc welding. The shielded-arc process with 9000 lb. of covered electrodes was used.

Steam hoisting equipment is used on the barge. The heavy load line, light load line and topping lift are handled over a three-drum winch, while a two-drum winch operates the swinging line. These winches are fitted with niggerheads for moving the barge. It can also be handled with a small towboat.

The boiler is of the Scotch Marine type, 125-lb. working pressure, burning fuel oil. The company proposes to install steam pumps for trimming ballast and then can use the barge hull when necessary for storing fuel oil pumped from ships being repaired.

The barge was designed and constructed under the supervision of Captain Angus Marshall, President of the Pennsylvania Shipyards Company, and C. T. Samuelson, General Superintendent. John Kimlock, Machinist Superintendent, J. O. Aubey, Hull Superintendent and Ben Brown, Welding Superintendent, had general charge of the work.

Stainless Steel Fractionating Tower Built by Arc Welding

One of the first large pressure vessels ever built of arc-welded stainless steel has been completed by The Foster Wheeler Corporation at their Cleveland, Ohio, shops.

This is a fractionating tower constructed for the distillation of fatty acid.

The tower is 59 ft. 6 in. high and 6 ft. 6 in. in diameter. Eighteen-eight stainless steel was used for the entire structure including the 29 bubble trays.

Shell plates are $^3/_8$ in. thick. Horizontal welds were made with a double vee.

The tower was built in two sections as shown in Fig. 10. A butt strap was welded on the ends of the section for connection on erection.

Figure 11 shows the bubble trays which were also fabricated entirely by welding. These trays rest on 2 x 2 x $^3/_{16}$-in. angles welded to the inside of the vessel, as shown in Fig. 12.

All welding was done by the shielded-arc process using Stainweld A electrodes.

On completion, the tower was tested with 25 lb. of air pressure after filling $^1/_2$ full with water. Approximate weight of the tower is 20 tons.

Large Fractionating Tower Built by Arc Welding

Figure 13 shows a huge fractionating tower 10 ft. in diameter and 58 ft. high. It was completely arc welded by the Struthers-Wells Company.

Shell thickness of the tower is $^3/_4$ in. while the heads are $^7/_8$ in. On completion

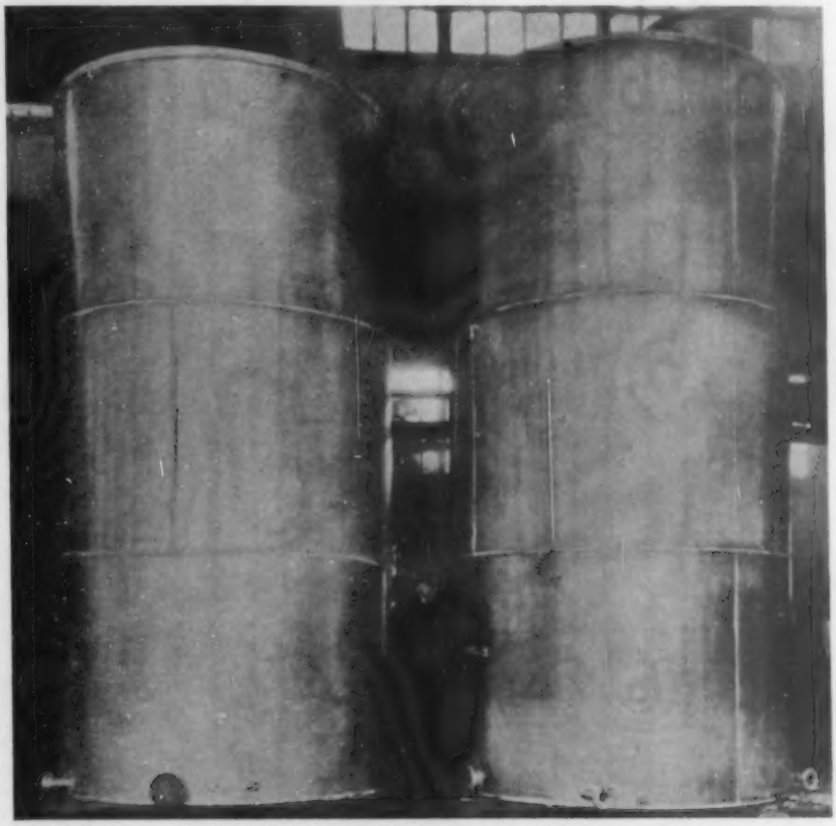


Fig. 6—These Welded Aluminum Tanks Were Built for the Storage of Acetic Acid

Fig. 7 (Below)—Aluminum Tanks and Kettles Fabricated by the Electric Arc Ready for Shipment

Fig. 8 (Left)—General View of Arc-Welded Barge Derrick Showing After Ballast Tanks Filled to Offset Load. The Derrick Was in Position to Lift One of the Steel Barges Shown in the Background

Fig. 9 (Right)—The Barge Derrick Is Shown Removing a Six-Ton Stack from a Tow Boat. This Operation Would Be Very Difficult for Locomotive Crane to Handle

Fig. 10—Arc Welding the 18-8 Stainless Steel Fractionating Tower

Fig. 11—Bubble Trays Are Sturdily and Economically Built by Welding

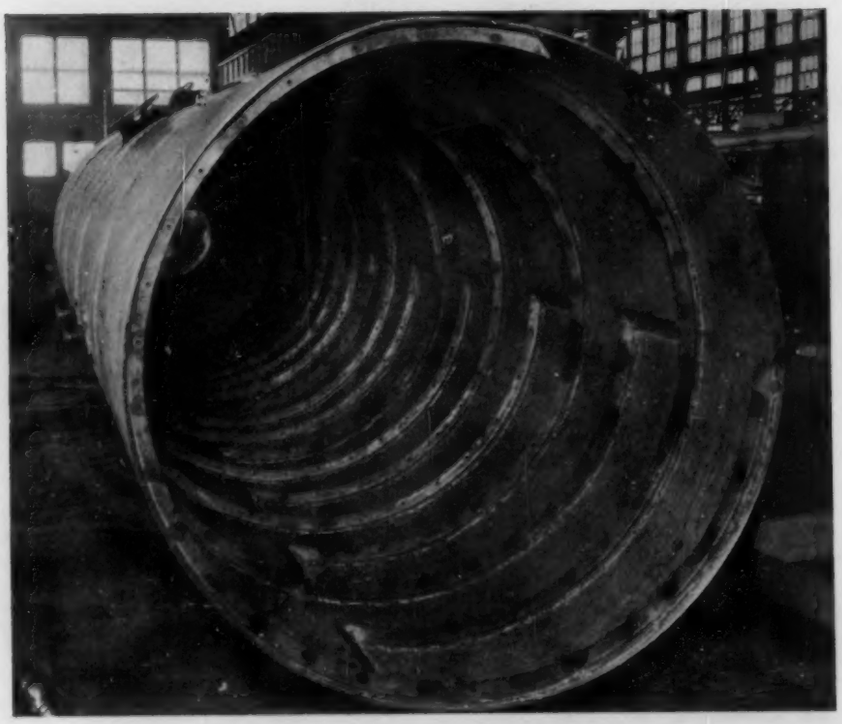


Fig. 12—The Inner Angles Support the Bubble Trays

of the welding the entire unit was heat treated. The column was shipped to Canada for oil refinery service in connection with the Dubbs cracking process.

Unique Remote Control for Arc Welders Cuts Welding Costs

Savings up to $500 per year per welder, higher quality welds and increased weld output are results claimed for a new remote control device for arc-welding machines. No additional cables or other apparatus need be carried by the operator.

The operator taps the electrode on the work several times—the voltage is automatically raised! A larger number of taps and the voltage is lowered! Thus, by merely tapping the electrode and by making and breaking the electrical circuit the current output of the generator is controlled.

With this control the operator can work at any distance from the machine and regulate the current accurately without making trips back and forth to adjust the controls.

When work is begun in the mornings, the welder is cold. After the machine is warmed up the current setting should be changed. Without remote control, the operator either uses the original setting with resultant lower speeds or makes a trip to the machine, thereby wasting time. Changing from horizontal to vertical welding or vice versa demands a change in electrode sizes. If the operator is working in the hold of a ship, for example, this change, requiring a resetting of the controls, probably means many minutes of lost time.

In shipyard work, the average welding operator spends approximately 15 per cent of his time in actual welding.

There is a definite and substantial saving in time wherever welding is done at a distance from the machines, as in the case of shipyard and structural work (see Fig. 14), boiler and tank shops, pipe-lines, steel mill work and dozens of other applications.

The highest quality weld metal is assured with this control, since there is no temptation on the part of the welder to use the original current setting rather than return to the machine and reset the controls. It permits the use of the most efficient electrodes and therefore insures the highest possible speeds.

The mechanism is encased in a small box which may be quickly attached to the welder voltage control. No additional apparatus of any kind is necessary. The regular hand controls may still be used as desired.

Figure 14 shows difficulty for operator to go to the machine to adjust his current.

Gantry Crane Built by Welding

Construction of an arc-welded gantry crane, said to be the first of this type to be built entirely by welding, has been completed by the Shaw-Box Crane and Hoist Company, Inc., Muskegon, Michigan.

The complete crane weighs approximately 150 tons and has a boom 96 ft.

in length. The boom carries a 55-in. lifting magnet or a clam shell dipper.

As shown in the accompanying photographs, the crane operates on four swivel trucks. This permits operation on curved as well as straight tracks. Rails are spaced 20 ft. from center line to center line.

Figure 15 shows the crane on completion. Note the lattice type all-welded boom. When in a vertical position, the height of the lift is 123 ft.

In Fig. 17 may be seen the hoisting equipment. The hoist is entirely arc welded. Note the simplicity of the construction of the frame and the gear guards.

Figure 16 shows view of the crane under construction.

A few bolts were used for erection purposes but the complete structure is essentially of arc-welded steel construction. Welding was decided upon due to the simplicity of the process, speed of operations and saving in weight.

All welding was done with covered electrodes.

The crane is now in operation at the West Michigan Dock and Market Corporation, Muskegon, Michigan.

Fig. 13—Huge Fractionating Tower 10 Ft. in Diameter and 58 Ft. High

Fig. 14 (Right)—Difficult for Operator to Go to the Machine to Adjust His Current

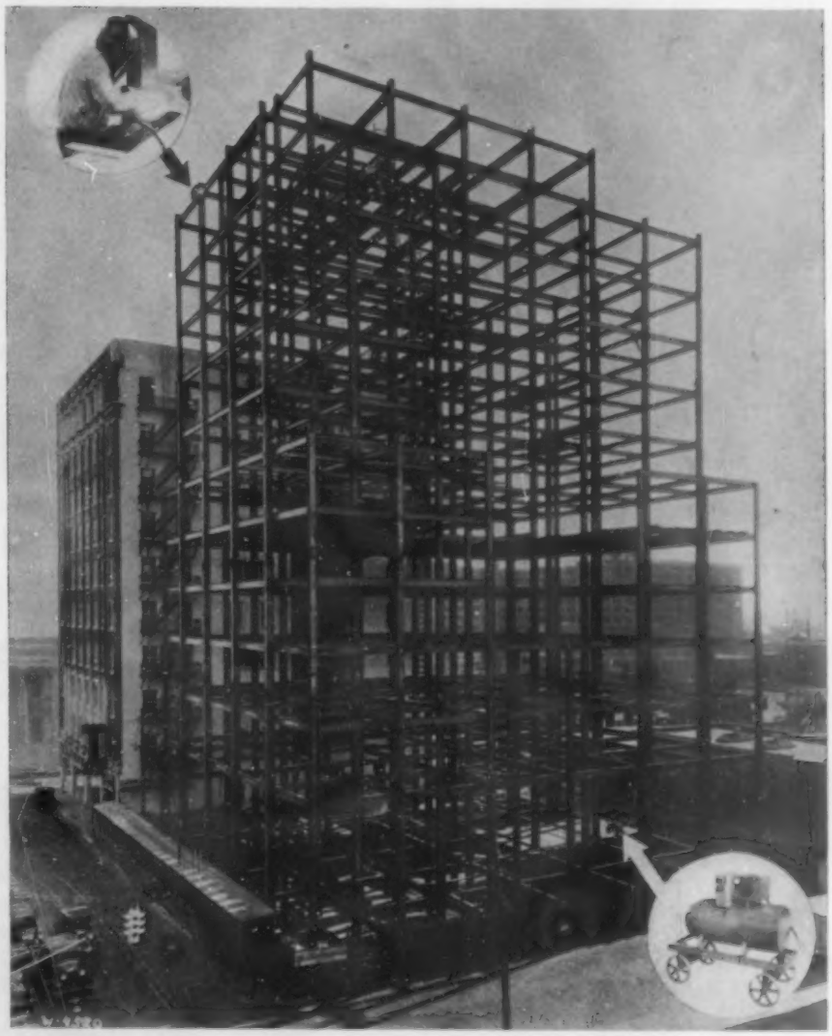
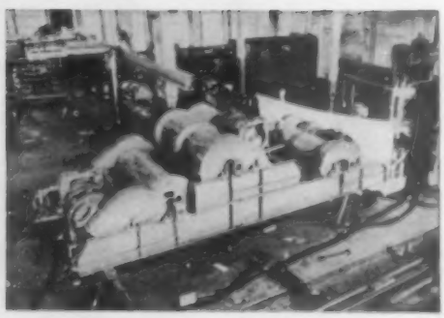
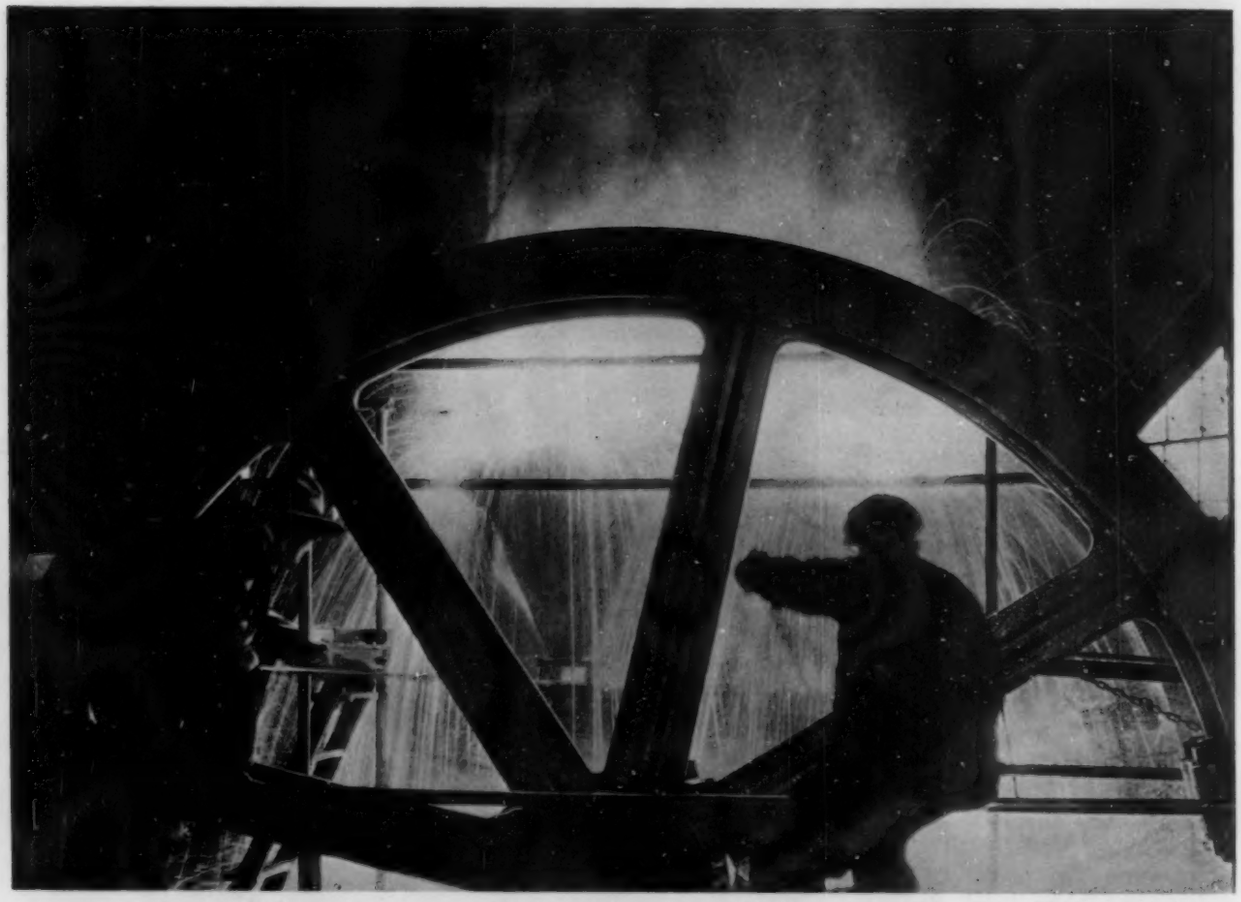


Fig. 15 (Left)—This Huge Gantry Crane Is Completely Arc Welded

Fig. 16 (Center)—Crane Under Construction. Total Weight Is 150 Tons

Fig. 17 (Right)—Arc-Welded Hoisting Mechanism





The Thermit Reaction-Welding of Main Drive Shaft at Cable Drive Power Plant of Market Street Railway Company, San Francisco, Cal.

Speedy Week-End Repair Restores Trolley Service for Monday A.M. Rush

By MERRITT L. SMITH

†Mr. Smith is Advertising Manager for the Metal and Thermit Corporation.

WHEN the main drive shaft at a power house of San Francisco's Market Street Railway Company let go recently, three street car lines were tied up completely. The break occurred at 3:30 o'clock on Saturday afternoon. To obtain a new shaft and install it would have taken weeks and would have meant a complete shutdown during that time.

A Metal & Thermit Corporation representative was called at his home, however, and camped on the job until the following Monday. A crew was recruited from the railway's track welding gang and preparation for welding was under way by 5 P.M. All Saturday night was consumed in preparing the fracture and assembling the welding equipment and materials. Preheating required until midafternoon on Sunday, when the weld was poured. By midnight the metal had cooled sufficiently to permit stripping off the molds, and by 3 A.M. Monday the job was completed. This was in ample time for cars to start running on their regular Monday morning schedules.

The shaft which fractured is $18^1/_2$ ft. long. It has a large drive gear in the center and a cable drum at each end and one each side of the drive gear. The break occurred at a shoulder of the drive gear seat and bearing where the diameters are $10^1/_2$ in. and $13^1/_2$ in. The repair was made with the shaft in place and required a minimum of dismantling. The results, aside from the speed with which the job was done, were remarkable in that after welding the shaft was less than $^1/_{32}$ in. out of alignment; less out of line, in fact, than it had been before. The repair is, of course, a permanent one and the shaft may now be considered as strong and as sound as new.

Manual on
FUNDAMENTALS OF THERMIT WELDING
Available Society Office
25 cents each

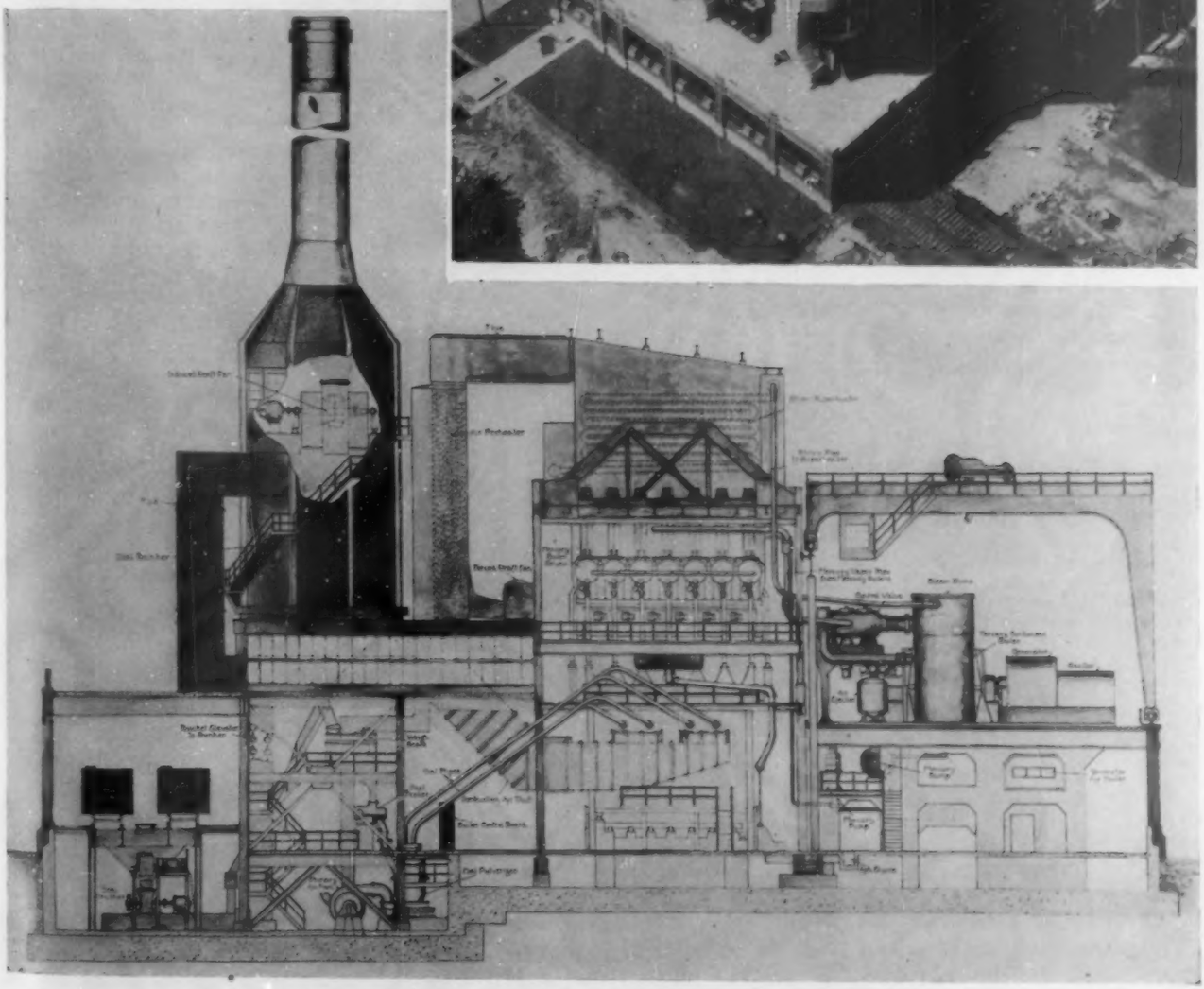
G-E Mercury-Vapor-Steam Plant Fusion-Welded Throughout

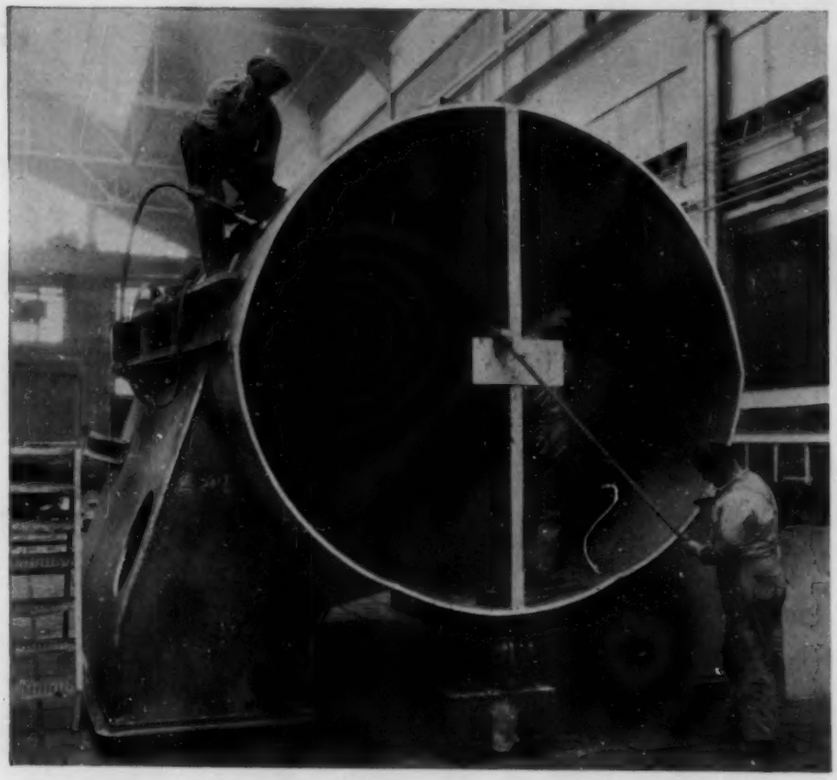
By R. H. ROGERS

✦Presented at the January 16, 1934 meeting, New York Section, A. W. S., by R. H. Rogers of the General Electric Company.

Aerial View (at Right) of General Electric Mercury-Steam-Electric Power Station at Schenectady, N. Y. The Installed Capacity is 26,000 Kw. and 650,000 Lb. of Steam per Hour

Broadside Cross Section (Below) through the G-E Mercury-Vapor-Steam Plant, Showing Arrangement of the Coal Handling and Pulverizing Equipment, Stacks, Draft Fans and Ducts, Mercury Boiler, Mercury Condenser Boiler and Other Units



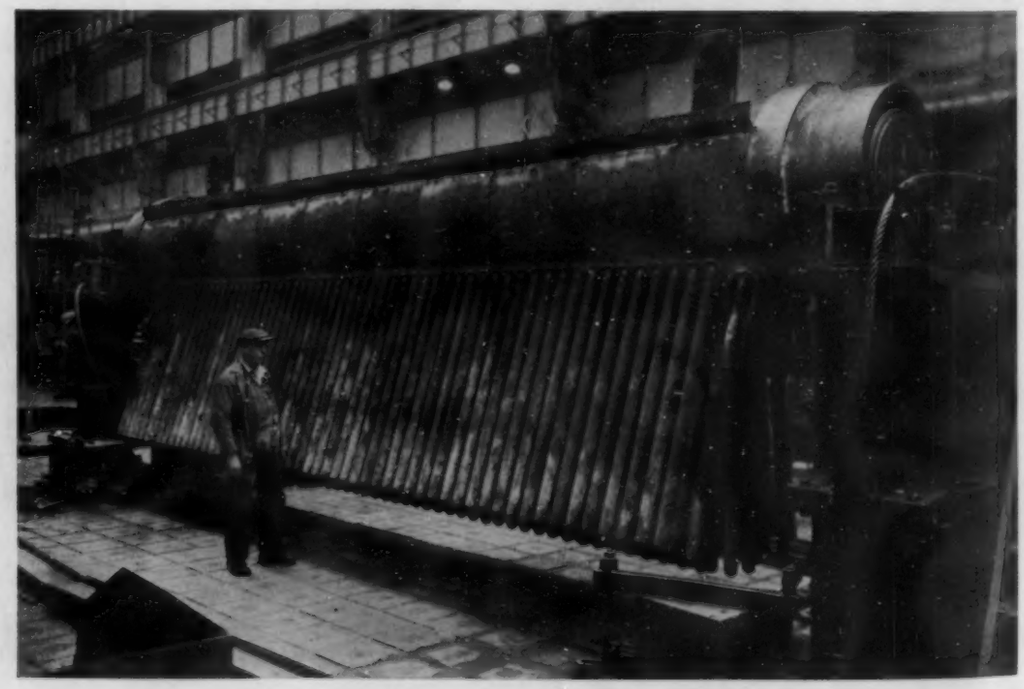


Shop Welding One of the Two Condenser Boilers Which in Service Are Stood on End and Connected to the Exhaust Hoods of the Mercury Turbine. The Condensing of the Mercury Vapor Generates High-Pressure Steam

THE new power station at the Schenectady Works of the General Electric Co. is unique in several ways. First, it is owned by an industry and operated by a utility, and the installed capacity is 26,000 kw. for the use of the New York Power & Light Co. and 650,000 lb. of steam per hour for the use of the General Electric Co. Second, it is a mercury-vapor-steam plant with a product of the mercury-vapor cycle of 325,000 lb. of steam per hour and 20,000 kw. Third, it is an outdoor station in that the main bulk of the steam and mercury boilers, the mercury and steam turbines and principal appurtenances are entirely exposed to the weather. Fourth, it is an arc-welded station throughout—structure, boilers, piping and equipment.

This paper is devoted principally to the A. S. M. E. Boiler Code welding as applied to boilers, piping and other pressure equipment. A brief description of the station is necessary in order to make clear the status of the items coming within the scope of the paper.

Two boilers are installed side by side, each with its own complement of coal-handling, storing, pulverizing and feeding equipment and other auxiliaries. One is a more or less conventional steam boiler for producing 325,000 lb. of steam per hour at 400 lb. 750 deg. The other is a



Seven of These Drums, Each with 440 Welded-in Porcupine Tubes, Make Up the Mercury Boiler. Only Two Leaks Developed During the Hydrostatic Tests of the 3080 Tube-to-Drum Welds Involved

mercury-vapor boiler with capacity for operating a 20,000-kw. turbine. The upper portion of its furnace has mercury walls and the lower portion has water walls which produce 85,000 lb. of steam per hour.

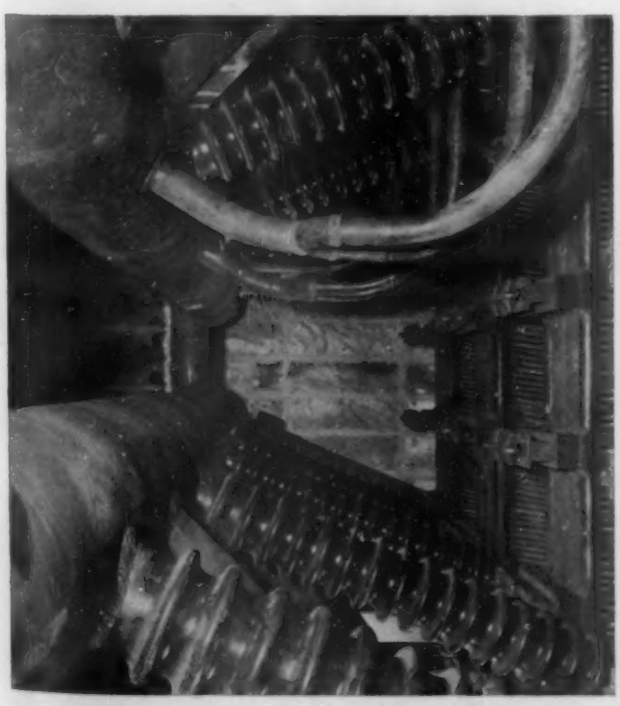
The mercury vapor has a pressure of 140 lb. at the boiler and 125 lb. at the turbine; the temperature is 958 deg. The condenser-boilers (which are the condensers for the mercury turbine) and furnace walls deliver 325,000 lb. of steam per hr. Steam transport lines involve $1^3/_4$ miles of high-pressure lines and water return lines carried in tunnels and on bridges to the older power stations from which it is distributed for testing, manufacturing and heating.

The structural work was fabricated and erected by the American Bridge Co., and the piping by the Pittsburgh Piping & Equipment Co. The mercury turbine equipment and accessories were fabricated in the General Electric plant. From the regular welding forces of the General Electric Co. some 30 men were qualified through the Hartford Steam Boiler Inspection & Insurance Co. for Class I code welding. Of these, six were employed by the Pittsburgh Piping & Equipment Co. for four months in erection work.

Mercury Boilers Require Welding of 3080 Tube Joints

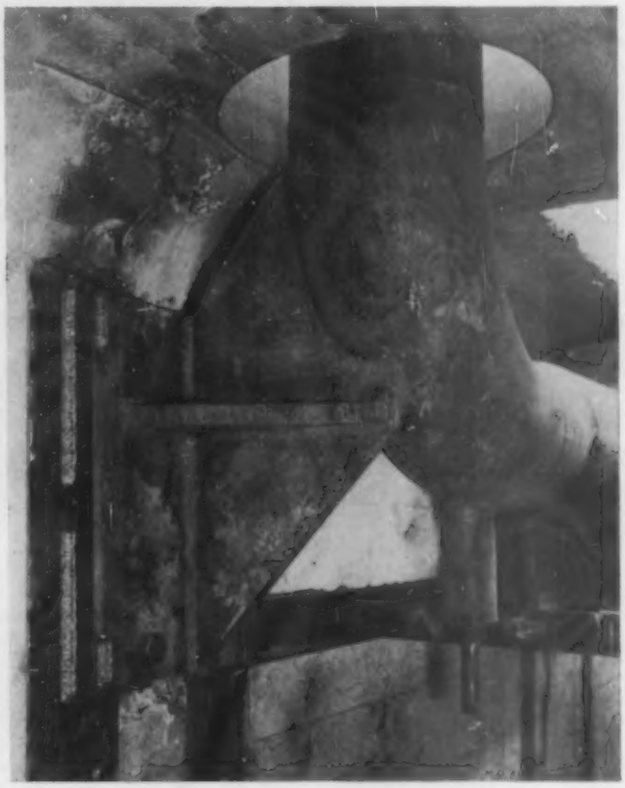
Detail specifications were prepared covering the procedure for qualifying welders and for the shop and field welding as well.

The mercury boiler consists of seven horizontal parallel drums of 30-in. welded pipe, 4 in. thick, suspended from trusses. Down hanging from each drum are 440 porcupine tubes welded inside the drum. In spite of the fact that the welders had to work in this 30-in. diameter space under forced ventilation only two leaks developed during hydrostatic test of the 3080 tube joints involved. The mercury liquid heaters and mercury furnace walls are examples of intricate shop fabrication. Among the other heavy units code-welded in the shop were the governor and safety valve body for the mercury turbine and the mercury turbine condensers.



Mercury Vapor Pipes (Above) from Seven Drums to Two Headers. The High Temperature, 958 Deg. F., Introduced Expansion Problems That Were Met by the Use of Corrugated Pipes

Welded Pipe Bend and Anchor Located Where the 400-Lb. 750-Deg. F. Steam Line Goes Up from the Tunnel to the Bridge



The piping involved carries liquid mercury, mercury vapor, steam at 400 lb. 750 deg., water at 600-lb. pressure as well as pipes for oil, gas, pulverized fuel and air. In general, the pipe is extra heavy and ranges from 1 to 18 in. in diameter. Flanges were avoided wherever possible; flangeless valves were used and long radius bends prevail at the turns.

High-Pressure Steam Lines of Major Interest

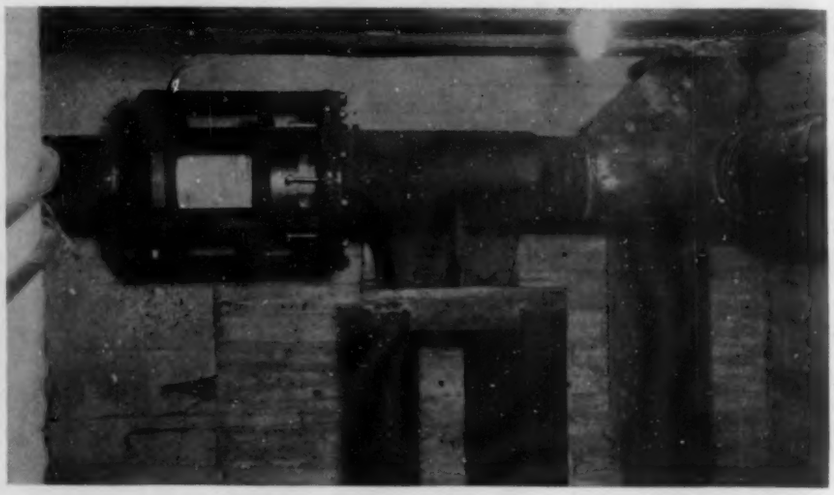
Among the many features of interest, one of the most important was the design of the steam lines between the power station and the General Electric works. These lines convey steam for heating, turbine testing and for manufacturing purposes from the new power plant to distributing points in two old power stations. The total distance involved is 3735 ft., requiring the installation of 4865 ft. of 14-in. high-pressure lines and 4433 ft. of condensate return lines, mostly 8 and 10 in. Steam is delivered at 400 lb. and 750 deg. F. at a maximum rate of 500,000 lb. per hour. The transmission of so much energy through this distance together with the high temperatures, high pressures and the accompanying expansion problems made this a major piece of work, adjunct as it is to one of the most interesting power stations in the world.

The steam and return lines are carried in a reinforced concrete tunnel. Short sections where entry is made to the old power stations are carried on skeleton bridges, because they cross various obstructures that precluded the use of tunnels.

In service, the 14-in. high-pressure lines contain $2^1/_2$ tons of steam, traveling at a speed of 4000 ft. per min. The temperature rise to 750 deg. F. involves, in the 4865 ft. of 14-in. pipe, a total linear expansion in the neigh-

borhood of 30 ft. with a potential pipe thrust of 400,000 lb. Without insulation, the radiation at 750 deg. F. would be the equivalent of more than 20,000 kw. equal to the total output of the mercury turbine. These figures make evident the responsibility of the anchorages, the expansion joints, the welded joints and the insulation.

The high-pressure piping is seamless, has a $^1/_2$-in. wall and the 35-ft. lengths weigh about 2300 lb. It was tack-welded to form 200-ft. lengths, and the welding of the joints was completed as the sections were rotated. Position welds joined them to flangeless slip expansion joints which in turn were welded to H-sections embedded in the tunnel side wall, thus providing a rigid anchorage. Self-sealing packing is used under light mechanical pressure as the steam pressure tends to press the truncated-cone rings against the pipe. The joint provides for 18-in. expansion, of which from 14 to 18 in. are actually used.



Expansion Joint, Roller Support and Anchor at Turn on 18-In. Pipe-Line in the Tunnel. The Pipe Is Chromium Plated at the Joint. Joints Are Located Every 200 Ft. to Take Care of a Total Expansion of More Than 30 Ft.

Weld-fabricated compound roller supports are located under the pipe at 25-ft. intervals. Approximately 22 90-deg. bends were used; those leading to the bridges are of 12-ft. radius. In general, anchor brackets were welded to the short radius bends and in turn to H-frames embedded in the concrete walls or roof.

Two kinds of construction were used for the bridges. The parts nearest the tunnel are built to carry the pipe by suspension, to allow for the expansion of the vertical runs. The pipe next to the buildings is mounted on top of the bridges. A continuous H-section is laid between the bridge and the pipe in order to relieve the structure of possible expansion strains. Should an expansion joint in the pipe fail to slip, the strain will be placed on the practically independent H-section rather than on the bridge structure proper.

During the transition period it was necessary to deliver steam for heating factory buildings as the boilers were being removed from one old station. This necessitated immediate insulation of the pipes as the bare-pipe radiation would have dissipated most of the heat. The insulation was completed before the joints were tested, and upon applying the 225-lb. pressure then available no leaks developed.

Expansion Roller Support Stands Welded in Place

Stands for the expansion roller supports were fabricated and welded in place. The pipe was brought in through the hatchways and hauled to location on trucks. Fusion rings 1 in. wide by $^1/_8$ in. thick, rolled from strip, were tack-welded in the delivery end of each pipe, the welds being made at the inside edge of the ring within the pipe. The lengths were then lifted onto the stands and placed on temporary roller dollies. Six lengths, with the last one cut to make approximately 200 ft., including the chromium-plated sliding section in the expansion joint, were strongly tack-welded together at six points at each joint. A split gear was clamped on, and the 200-ft. length was rotated at about one revolution in 6 min., or at a peripheral speed of a little over 7 in. per min., by a small adjustable-speed motor operating through a gear reducer and chain.

Welding of roll joints involved five passes using heavily coated electrodes, starting with $^3/_{16}$ in. at 200 amp. and finishing with $^1/_4$ in. at 275 amp. After each pass the slag was chipped off with an air tool which provided some peening effect. The first pass was laid straight and succeeding passes were oscillated increasingly as required to fill the 60-deg. beveled groove. The last pass was slightly crowned and was about $^3/_4$ in. wide. All welding was done by hand, using single-operator motor-generator sets.

One Position Weld at Each Expansion Joint

Only one position weld was required at each expansion joint, that being where the 200-ft. line was welded to the stationary member of the expansion joint. These position welds were made with coated electrodes in four passes. The weld passes were started at the bottom of the joint and finished at the top, alternating the halves. The succeeding passes were started and finished at staggered points to prevent concentration of starting and finishing joints.

After the position welds, the roller dollies were removed and the roller support members were welded to the underside of the pipe and to the stands. The expansion joints were then anchored by welding. Fitted blocks were welded between the embedded H-section and the joint anchorage bases.

The 8-in. and 10-in. water pipe was handled in the same manner as outlined above except that the expansion joints were spaced 400 ft. apart. The expansion joints were fitted with anchorage members by the manufacturer but the anchorages on the bends were fabricated at the Schenectady works. The vertical risers, two of 28 ft. and one of 34 ft., were position-welded with the heavily coated electrodes.

Nine test specimens from tested welds were subjected to reduced-section tension tests, nick-break tests and bend tests. Specifications, covering in detail the entire welding procedure, were rigidly adhered to throughout the fabrication of these pipe-lines. It is significant that not a single leak developed under steam test among the great number of roll welds and horizontal and vertical position welds.

The electrodes used on the pipe and accessories amounted to 2155 lb. The welding cost was 3 per cent of the cost of the line exclusive of tunnel and bridge construction.

The intricate detail, erection difficulties and the magnitude of the work can best be appreciated by an inspection of the many pictures taken during the construction period.

Boulder Dam Cylinder Gate and Nose Liner Welding Problems

By CHAS. H. JENNINGS

†Paper presented at a special meeting of the Chicago Section, A. W. S., Feb. 20th, by Chas. H. Jennings of the Westinghouse Research Laboratories.

Introduction

THE construction of the Boulder Dam across the Colorado River at Black Canyon and its accompanying projects is one of the outstanding examples of modern engineering, the dam and reservoir of which are constructed under a total authorized expenditure of $70,600,000 and when completed will be the highest and largest dam ever constructed and will create the largest artificial lake in the world. (When filled the reservoir will contain about 11,000,000,000,000 gal. of water.)

The control of the water from the reservoir to the four 30-ft. diam. penstocks which distribute it to the turbines and outlet works is arranged for by four 30-ft. inside diameter reinforced concrete intake towers equipped with two cylinder gates each. The lower gate is located on the ground level and the upper gate is located 150 ft. above. The average maximum water pressures on these gates are: upper gates, 82 lb./sq. in.; lower gates, 142 lb./sq. in.

The cylinder intake gates and accompanying nose liners (see Fig. 1) are made entirely of welded plate construction and together comprise the largest welded job of its type undertaken. (3,440,000 lb. of steel plate and 530,500 lin. in. of weld are required in the fabrication of this job.) The welding problems encountered in a project of such large magnitude are of particular interest to those interested in welding and it is the purpose of this article to briefly discuss a few of them.

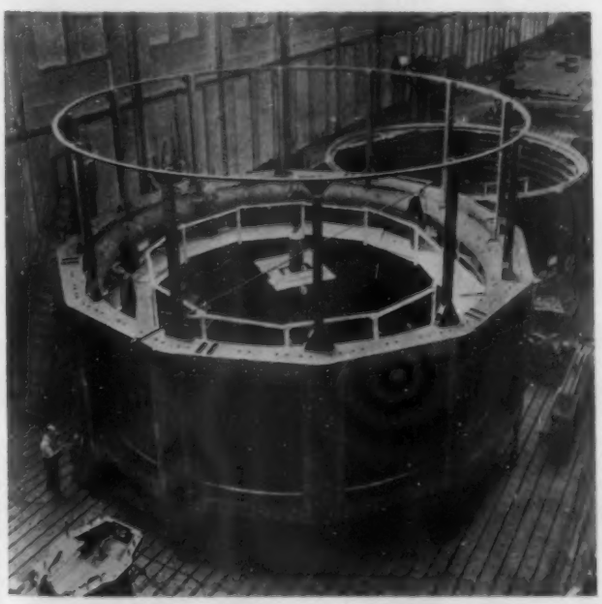
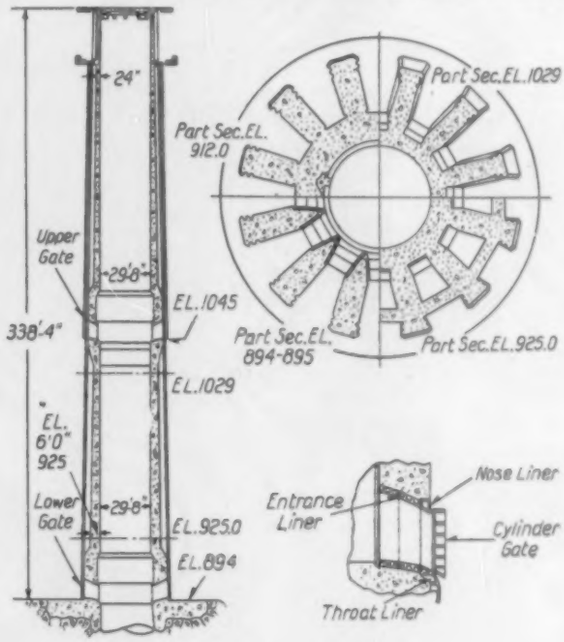


Fig. 1—Assembled View of Gate and Nose Liner

Fig. 2—Section of Intake Towers Showing Location of Gates



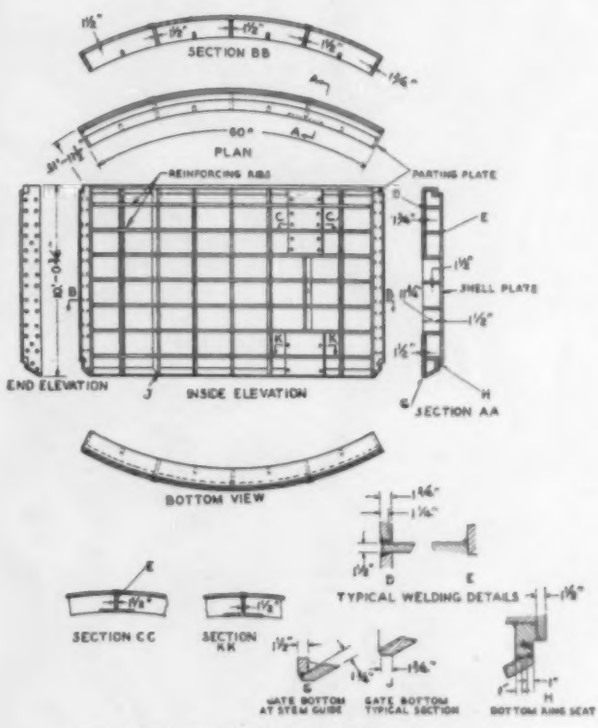


FIG.3 - UPPER CYLINDER GATE SEGMENT DETAIL

Design of Cylinder Gates and Nose Liners

In order to thoroughly appreciate the magnitude and importance of the cylinder gates and nose liners it is necessary to understand their location and function in the intake towers. Figure 2 is a sectional view of an intake tower showing the location of the gates, nose liners, entrance liners and throat liners. The entrance

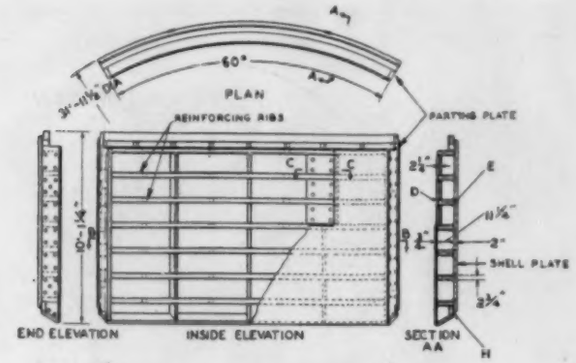


FIG. 4 - LOWER CYLINDER GATE SEGMENT DETAIL

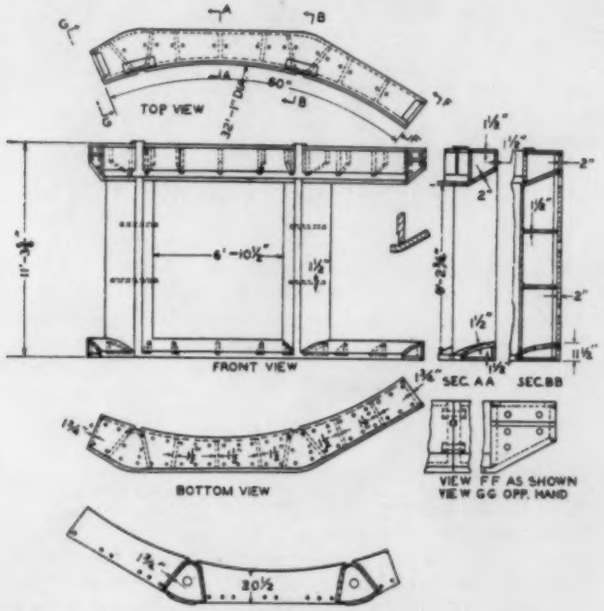


FIG. 5 - UPPER NOSE LINER SEGMENT DETAIL

liners afford a metal path for conducting the water from the surrounding reservoir through the walls of the intake towers. There are twelve entrance liners equally spaced around the tower at each gate location, thereby allowing twelve inlets for the water.

The nose liners bolt to the inner edges of the entrance liners, bridge the section of concrete between the entrance liners and afford a guide for the cylinder gates.

The gate proper is essentially a hollow cylinder which slides up and down inside the nose liner assembly in the manner of a valve. Both gates and nose liners are equipped with monel metal seats so that when the gates are lowered they come in contact and effectively seal the openings and prevent water from passing from the reservoir into the towers. To permit the water to flow through the towers into the penstocks, the gates are raised by means of screw hoists located in the top of the towers.

Drawings for the weld fabricated gates and nose liners are given in Figs. 3 to 6, inclusive. It will be noted that the upper and lower gates and liners are similar in design and vary primarily with regard to weight of construction. The lower gates have a metal liner which is attached by screws to their inner periphery for the purpose of making a smooth surface, thereby reducing friction losses when the upper gates are in use. This liner is not designed to add strength to the gates.

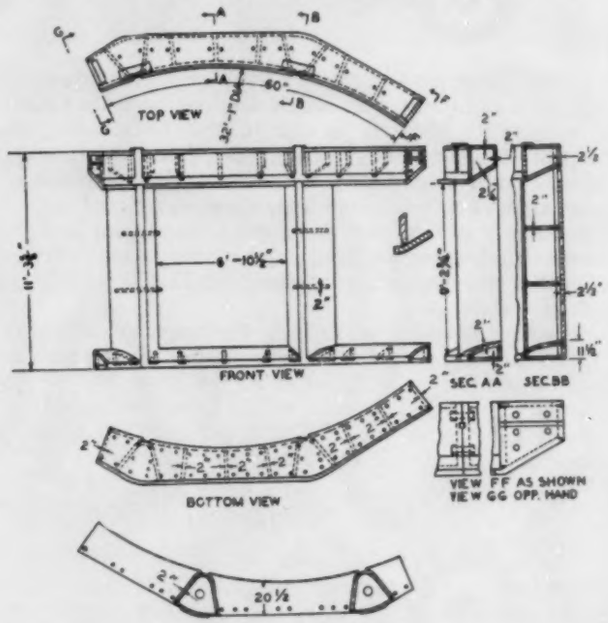


FIG. 6 : - LOWER NOSE LINER SEGMENT DETAIL

The gates and nose liners are fabricated in segments, six of which are required to make a complete unit. After each segment is welded it is strain annealed. (Figure 7 shows a gate segment and nose liner segment ready to go into the electric annealing furnace.)

The gate and nose liner segments are assembled to form the completed structures by means of bolts. No welding is required on the gates after the segments have been annealed. The only welding required on the nose liners is a small seal weld at the parting joints after erection. Figures 8 and 9 show complete gate and nose liner assemblies.

Welding and Plate Specifications

The welding specifications for the job are very brief and are reprinted below, exactly as given in the United States Department of Interior (Bureau of Reclamation) Specification No. 541.

"*Preparation for Welding.*—Plates to be joined by welding shall be accurately cut to size and, where required, shall be rolled or pressed to the proper curvature in accordance with dimensions shown on the drawings. Plate for the vertical column portion of the nose liners, and warped plates for the top and bottom of the water passages, shall be heated for forming. The dimensions and

shape of the edges to be joined shall be such as to allow thorough fusing and complete penetration, and plates shall be planed if necessary to accomplish this result. The surface of the plates for a distance of one-half inch back from the welding edge shall be thoroughly cleaned of all rust, grease and scale, to bright metal. Flame cutting may be used in the preparation of the various members providing this operation is performed by machine. Any contour irregularities at critical stress points shall be removed by welding and grinding.

"*Welding.*—All welding shall be performed in the shop and shall conform to the current 'Rules for the Fusion Process of Welding,' Class 2 of the A. S. M. E. Boiler Construction Code, Unfired Pressure Vessel Section.

Fig. 7—Gate and Nose Liner Segments Ready to Be Annealed

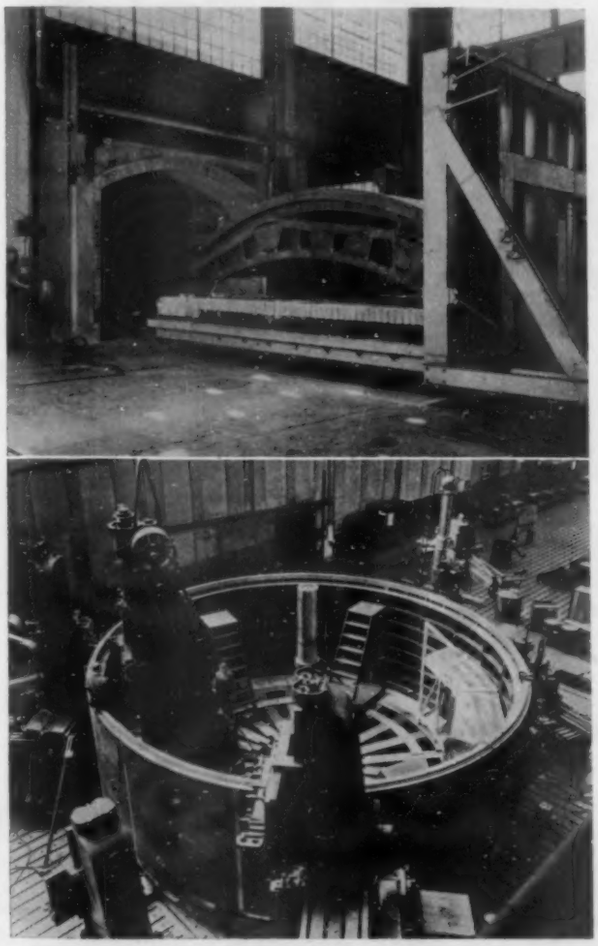


Fig. 8—Complete Cylinder Gate Composed of Six Segments Bolted Together

The welding process shall be under control at all times and there shall be no greater evidence of oxidation in the metal of the welds than in the metal of the original unwelded plates. Each deposited layer of weld metal shall be thoroughly cleaned before applying the succeeding layer. Welding of all joints shall be done by a process that will exclude the atmosphere from the metal while in its molten state. The finish of welded joints shall be reasonably smooth and free from grooves, depressions and other irregularities. All welds shall be thoroughly peened. The dimensions of welds are not shown on the drawings, but the contractor shall so proportion all welds that the full strength of the connected members will be developed.

"*Welded Joints.*—The welded joints shall be so designed that the stress in the weld metal after heat treatment shall not exceed 10,000 lb./sq. in. in tension and compression, or 7500 lb./sq. in. in shear.

"*Qualification of Welders.*—The contractor shall be responsible for the quality of work done by his welding organization and shall employ on the work only skilled welders capable of meeting the qualification tests for welders as specified in the 'Rules for the Fusion Process of Welding,' Class 2 of the A. S. M. E. Boiler Construction Code, Unfired Pressure Vessel Section. The contracting officer shall have the right at any time to call for and witness the making of test specimens by any welder, in accordance with the above code, and to observe the physical tests, which shall meet the requirements for Class 2 welding.

"*Heat Treatment.*—After all welding of each completely fabricated plate steel part has been completed, the part shall be stress-relieved at the proper temperature for a period of time not less than one hour per inch of maximum thickness of metal, and shall be allowed to cool slowly in the furnace. After heat treatment and machining have been completed, and before final inspection and painting, the outside unfinished surfaces shall be shot-blasted or sand-blasted to bright metal. With the approval of the contracting officer, imperfections may be removed by chipping to sound metal and repaired by welding. All such repairs shall be made before heat treatment."

The steel plate specifications required that all steel plates be made by the open-hearth method, that they contain 0.2 to 0.3% Cu and that their yield strength be not less than 24,000 lb./sq. in. (the yield strength being designed by 0.2% permanent elongation of the original gage length). The actual physical properties of the plate material used was approximately as follows: yield point 27,000 lb./sq. in.; tensile strength 58,500 lb./sq. in.; elongation 36% in 2 in. The approximate chemical analysis was: C −0.23, Mn −0.056, P −0.029, S −0.029, Cu −0.24.

Training the Welding Operators

The welding specifications as given above required welding of A. S. M. E. Boiler Code Class 2 quality. This required that only welders that had passed the necessary test requirements for this class of welding could work on the job.

Fig. 9—Complete Nose Liner Composed of Six Segments Bolted Together

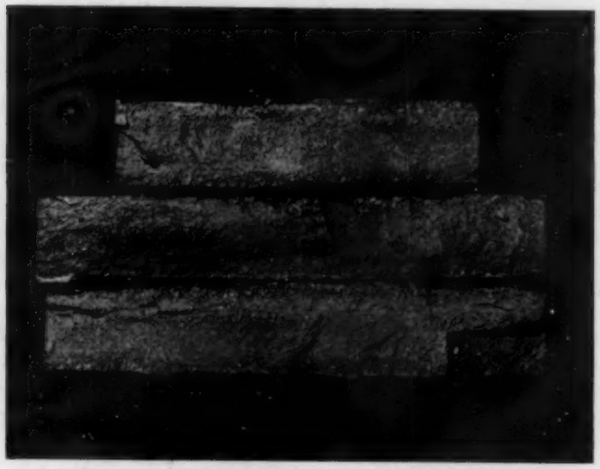


Fig. 10—Nick-Break Fractures of Welded Specimens

A course to train men for this class of welding should consist of a day of special instruction and demonstration, to thoroughly inform them of the proper welding technique and the quality of welding required, followed by five to ten days practice under the supervision of the instructor (the exact length of this practice period depends upon the ability of the welder).

Following the practice period each welder should be allowed to make a test plate. If a welder passes the tests successfully he is then fitted for this class of work. If he fails he should be given special instructions on how to correct his faults and should be required to practice for a few more days before being allowed to make another test.

The practice welding should consist essentially of butt welding $1^1/_2$-in. plates 15 in. long and subjecting them to a nick-break test. When a welder is capable of making welds giving a nick-break fracture free from gas holes, slag inclusions and poor fusion he should then be capable of making a weld that would meet all the requirements for tensile strength, ductility and soundness as specified by the Boiler Code. Typical nick-break fractures of the above-mentioned type are shown in Fig. 10.

In addition to making butt weld specimens during the practice period the welders should also be trained to make fillet welds, since most machine structures contain welds of the fillet type.

In all 80 qualified welders were employed in the construction of the cylinder gates and nose liners.

Welding Electrodes

The requirements of the A. S. M. E. Boiler Code for Class 2 welding (tensile strength by full section tensile specimen not less than the minimum specified tensile range of the plate, tensile strength by reduced section tensile specimen not less than 95% of the minimum specified tensile range of the plate, ductility by free-bend 20% elongation and nick-break fracture sound clean metal with not more than 6 gas pockets $^1/_{16}$ in. maximum diameter per sq. in. of weld surface exposed in the fracture), required that all welds be made with a high quality fluxed electrode. The electrodes used for welding the cylinder gates and nose liners actually produced welds superior to the quality required because the physical properties in all cases met the requirements of A. S. M. E. Class 1 welding.

The diameters of the electrodes used were $^3/_{16}$, $^1/_4$ and $^5/_{16}$-in. diam. The $^3/_{16}$-in. electrodes were used primarily for depositing the first beads in the bottom of butt welds where the gap was too narrow to obtain good penetration with $^1/_4$-in. electrodes. Electrodes of $^1/_4$-in. or $^5/_{16}$-in. diam., depending upon the size and location of the weld, were used to finish the butt welds. All fillet welds were made with $^1/_4$-in. diam. electrodes.

Tack welds used for holding the various parts of the structure together preparatory to welding were also made with fluxed electrodes. The electrodes in this case were of $^3/_{16}$-in. and $^1/_4$-in. diam.

Joint Designs

In discussing the design of the joints it is only necessary to consider the butt joints.

Resulting from the particular design of the structures (see Figs. 3 to 5) it was necessary to make most of the joints of the single bevel type. A few joints were of the single vee and double vee types but they were a very small percentage. The included angle between the kerfs of the single bevel joints was held as closely as possible to 45° and the included angle between the kerfs of the single and double vee joints was held to about 40°. At first thought these angles might seem small, but extensive tests and investigations revealed these designs to give the best results. The only difficulty that might be encountered by using small included angle joints of this type would be obtaining good penetration at the bottom of the joint. This difficulty was completely eliminated, however, by slightly spacing the butting edges wherever possible and/or by depositing the first beads with small ($^3/_{16}$-in. diam.) electrodes.

The advantages of the small included angle are as follows:

1. It reduces the amount of weld metal required in making a joint, thereby reducing the welding time and the cost.
2. The reduced amount of deposited weld metal reduced the local heating in the structure and reduced the residual stresses.
3. It cut down the maximum width of the joint and made it possible to weld the full width of the widest joints at a single pass without excessive weaving. It has been found that if a very wide weave is used with fluxed electrodes that the pool of molten metal becomes too large, thereby resulting in overheating of the deposited weld metal and excessive undercutting.

Welding Procedure

As this article is intended only to discuss the welding procedure and technique used in connection with this project, the details of forming and preparing the plates for welding will not be discussed; also, because the designs of the structures are so complicated, it is not possible in the space of this article to go into very great detail. As a result only the more important phases which are directly responsible for obtaining satisfactory results will be discussed.

A. Cylinder Gates

The upper and lower cylinder gate designs are essentially the same, consequently the same general welding procedure was used on both. As a result only the lower gates, which were the first to be fabricated, will be considered.

Since larger diameter fluxed electrodes could be used and greater welding speeds obtained by welding in the horizontal position, the gates were tilted during the welding process so that all the joints could be welded in such a position. When making fillet welds the struc-

Fig. 11—Fillet Welding on Gate Segment Details

Fig. 12—Welder Making Longitudinal Fillet Welds on a Gate Segment

tures were tilted approximately 45° in order to form a trough and assimilate a butt weld.

Tilting of the complete gate segments into the many necessary welding positions required many special jigs. All parts that could be individually assembled, before the complete assembling of the segments, were so made. This procedure made possible the use of simple fixtures such as shown in Fig. 11. The simplicity of the jigs and the small sizes of the parts welded in such cases aided greatly in increasing welding speeds. (Figure 11 shows welders depositing fillet welds to join spacers to the longitudinal reinforcing ribs of a gate segment.)

After welding the necessary individual details, the complete segments with the exception of the parting plates which are attached to the ends of the reinforcing ribs (see Figs. 3 and 4), were assembled in a jig and tack-welded together. The location of the tack welds are clearly shown in Fig. 12.

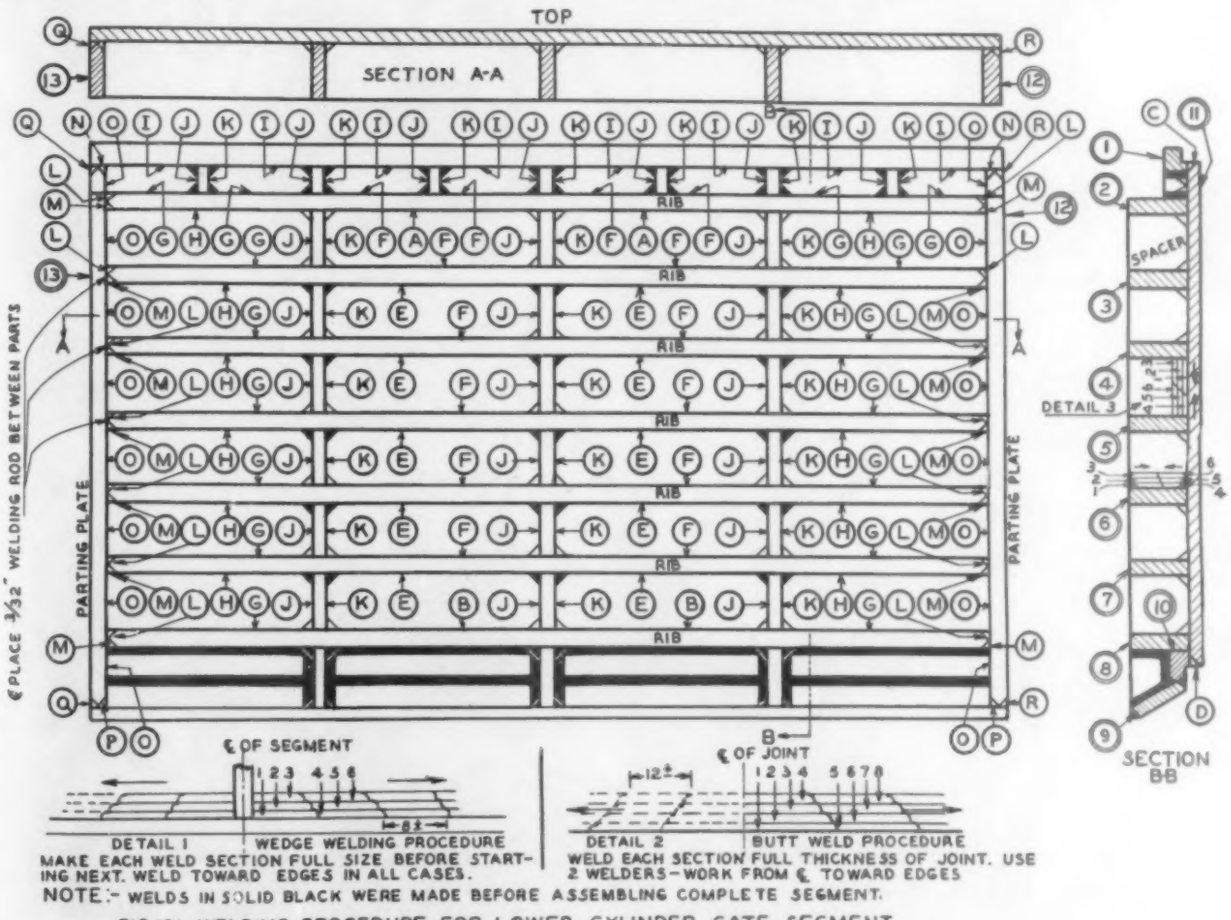

TOP
SECTION A-A
RIB
PARTING PLATE
℄ PLACE 3/32" WELDING ROD BETWEEN PARTS
SPACER
DETAIL 3
SECTION B-B
℄ OF SEGMENT
℄ OF JOINT
DETAIL 1
WEDGE WELDING PROCEDURE
DETAIL 2
BUTT WELD PROCEDURE
MAKE EACH WELD SECTION FULL SIZE BEFORE STARTING NEXT. WELD TOWARD EDGES IN ALL CASES.
WELD EACH SECTION FULL THICKNESS OF JOINT. USE 2 WELDERS—WORK FROM ℄ TOWARD EDGES
NOTE:- WELDS IN SOLID BLACK WERE MADE BEFORE ASSEMBLING COMPLETE SEGMENT.

FIG.13:-WELDING PROCEDURE FOR LOWER CYLINDER GATE SEGMENT

After the gate segments were tack-welded together they were removed from the assembly jig and the reinforcing ribs, the rib spacers and the shell plate completely welded together. This being completed, the ends of the ribs were machined and beveled and the parting plates attached and butt-welded into position. The exact welding procedure as outlined for the welders is shown in Fig. 13. The instructions to accompany Fig. 13 are as follows:

1. Tilt segment about top.—Make fillet welds (*A*) between members 2 and 11, using the wedge procedure given in detail 1, Fig. 13.

2. Tilt segment about bottom.—(*a*) Make fillet welds (*B*) between members 8 and 11 using the wedge procedure given in detail 1, Fig. 13. (*b*) Make butt weld (*C*) between members 1 and 11, using the butt weld procedure given in detail 2, Fig. 13.

3. Stand segment on top.—(*a*) Make butt weld (*D*) between members 10 and 11 using the butt weld procedure given in detail 2, Fig. 13. (*b*) Make fillet welds (*E*) between members 3–4–5–6–7 and 11, using the wedge procedure given in detail 1, Fig. 13.

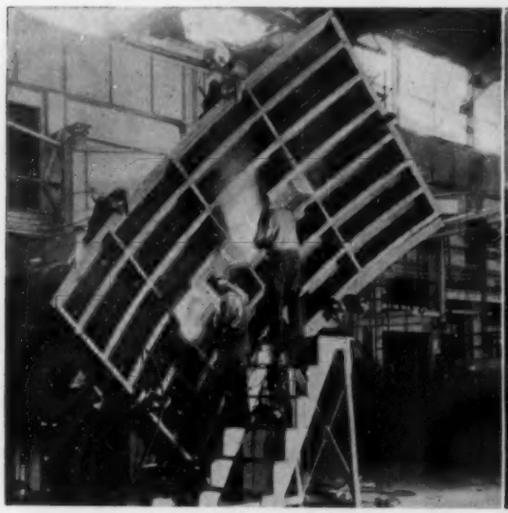


Fig. 14—Welding Rib Spacers in Place with Fillet Welds

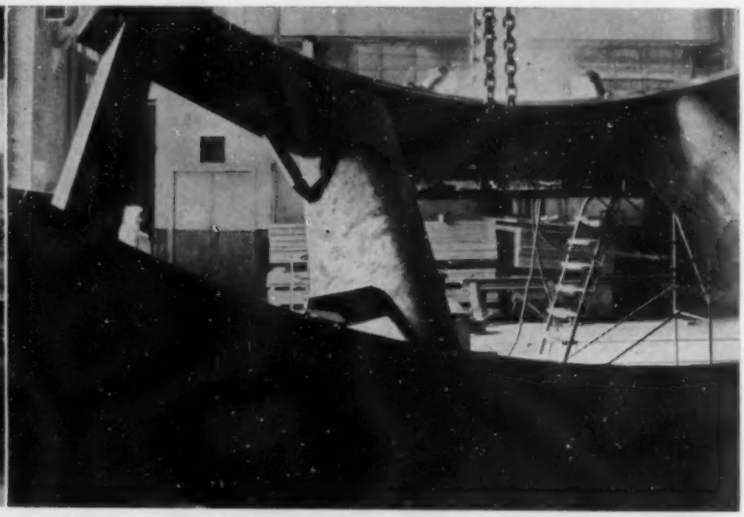


Fig. 15—Welders Working on a Nose Liner Segment Supported by a Crane

4. Tilt segment about bottom.—(*a*) Make fillet welds (*F*) between members 2–3–4–5–6–7 and 11 using the wedge procedure given in detail 1, Fig. 13. (*b*) After completing welds (*F*) make fillet welds (*G*) between plates 2–3–4–5–6–7–8 and 11, using the wedge procedure given in detail 1, Fig. 13.

5. Tilt segment about top.—(*a*) Make fillet welds (*H*) between members 2–3–4–5–6–7 and 11 using the wedge procedure given in detail 1, Fig. 13. (*b*) After completing fillet welds (*H*) make fillet welds (*I*) between members 1 and 11, using the wedge procedure given in detail 1, Fig. 13. Work from center of segment toward ends.

6. Stand segment on end.—Make fillet welds (*J*) between all spacer plates and member 11, using the procedure given in detail 3, Fig. 13.

7. Stand segment on opposite end.—Make fillet welds (*K*) between all spacer plates and member 11 using the procedure given in detail 3, Fig. 13.

8. After completing fillet welds (*K*) the ends of the ribs 2–3–4–5–6–7 and 8 are machined and beveled and the parting plates 12 and 13 attached. The segment is then stood on its bottom and the butt welds (*L*) between parting plates 12 and 13 and ribs 2–3–4–5–6–7 and 8 are made by using the procedure given in detail 4, Fig. 13.

9. Stand segment on top.—Make butt welds (*M*) between parting plates 12 and 13 and ribs 2–3–4–5–6–7 and 8, using the procedure given in detail 4, Fig. 13.

10. Place segment in jig (see Fig. 14).—(*a*) Make all fillet welds between spacers and ribs 2–3–4–5–6–7 and 8, using the procedure given in detail 4, Fig. 13. (*b*) Make butt welds (*N*) between parting plates 12 and 13 and member 1. (*c*) Make butt welds (*O*) between parting plates 12 and 13 and member 11 using a procedure similar to that given in detail 3, Fig. 13. (*d*) Make butt welds (*P*) between parting plates 12 and 13 and members 9 and 10, using a procedure similar to detail 3, Fig. 13.

11. Stand on end.—Make butt weld (*Q*) between members 1–11-9 and 13 using the butt weld procedure given in detail 2, Fig. 13.

12. Stand on opposite end.—Make butt weld (*R*) between members 1–11–9 and 12 using the butt weld procedure given in detail 2, Fig. 13.

Figure 12 shows a gate segment tilted in approximately a 45° position so that the welder can easily make the fillet welds between the reinforcing ribs and the shell plate. Figure 14 shows a gate segment placed in a fixture capable of three-dimensional motion which was used to tilt the gate segments in order to weld the rib spacers in place.

In connection with the welding procedure outlined above it is desirable to discuss the reasons for adopting the particular sequence used.

It will be noted that both butt and fillet welds were in all cases built up in short sections the full thickness of the finished weld. The purpose of this was to prevent as much as possible the presence of any welds smaller than the finished size. Constructing welds by depositing single layers the full length of the joints was not practicable because the uneven heating and cooling of the thick heavy members would have caused the welds to crack. Constructing the welds so that all but the immediate sections being welded were full size prevented trouble from cracks resulting from uneven heating and cooling.

Making the long butt and fillet welds by always progressing from the center to the ends of the joint or segment had the advantage of allowing the ends of the

welded members to be more or less free to move. This freedom of movement eliminated cracks because it eliminated the presence of large residual stresses.

Referring to Fig. 13 and the above-outlined welding procedure it will be noted that the long butt welds *C* and *D* at the top and bottom of the gate segments were made first. The only welds made previous to these butt welds were 4 sections of fillet welds *A* and *B* (see Fig. 13). These welds were made solely for the purpose of preventing the top and botttom sections which had been welded previous to the assembling of the segment, from warping out of shape when depositing the butt welds. The large size of these butt welds resulted in considerable local heating of the segments. This local heating was of such a magnitude that it would have set up high thermal stresses and caused the longitudinal rib fillet welds to crack had they been made previous to the butt welds.

In addition to the above the following general rules were followed:

1. All layers of deposited weld metal were peened with a blunt-nosed peening tool operated by a light chipping hammer in order to reduce residual stresses and to clean the weld. This peening operation was carried out immediately after the deposition of each 6 to 8 in. of deposited metal. Peening in this manner before the deposited metal became cold gave better results.
2. Spots of poor fusion, undercut and inclusions were removed by chipping before depositing succeeding layers of weld metal.
3. After welding was once started on a gate segment it was continued to completion as nearly as possible without interruption. This procedure prevented the segments from being successively heated and cooled and consequently reduced the thermal strains.
4. All tack welds were chipped out during the main welding process. Although this procedure was not necessary in all cases it was found to produce the best results.
5. Special attention was given by each welding operator to all craters. For the best results it was found desirable to fill all craters before breaking the arc.

B. Nose Liners

The nose liners as shown in Figs. 5 and 6 were made in the same general manner as the cylinder gates. Wherever possible, individual sections, such as the noses and top-ring, were separately welded before being introduced in the general assembly. The general assembly was accomplished by placing the various parts in a jig and tack welding them together. During this assembling process numerous braces were added between the members to prevent their warping and distorting out of shape. Figure 15 shows the location of some of the braces applied.

In order to tilt the nose liners so that all welding could be done in a horizontal plane they were suspended by means of overhead cranes. This system afforded a quick cheap means of support and turned out to be highly satisfactory. Figure 15 shows several operators making fillet welds on a nose liner segment which is supported by a crane.

The complete welding procedure for the nose liners is too long and complicated to include in this article. It is sufficient to state, however, that the sequence of welding was arranged so as to develop the minimum amount of handling and the minimum amount of distortion of the finished product. The same general rules and methods of making butt and fillet welds as outlined for the cylinder gates were used in this case.

Annealing the Welded Parts

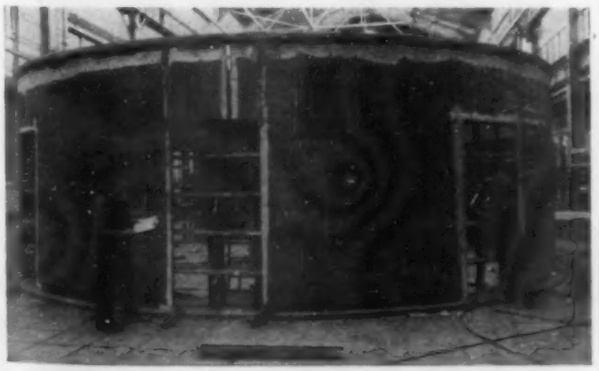
After completing the welding of each gate or nose liner segment it was strain-relieved in an electrically heated annealing furnace at a temperature of approximately 1300° F. The annealing cycle consisted of 18 hrs. to bring the furnace up to temperature, 3 hrs. soaking time at the required temperature and 22 hrs. to cool the furnace to 200° F. before removing the parts from the furnace. Figure 7 shows a nose liner segment and gate segment loaded on a car ready to be moved into the annealing furnace.

During the welding processes the gates and nose liners had a tendency to warp slightly out of shape. This condition was effectively corrected during the annealing process by placing weights on top of the segments and proper supports underneath them.

No trouble was experienced from cracked welds as a result of the annealing process.

Conclusion

Although this article has outlined and discussed only the welding problems encountered on one particular job it will be found that the procedures and rules developed to overcome these problems will be applicable to many other jobs. Particularly is this true in cases where the members joined are large and rigid. The splendid success of the applied procedure definitely establishes its merits as a satisfactory commercial welding procedure.



All-Welded Stator Frame

FOR BOULDER DAM

By Guy Bartlett

†Mr. Bartlett is connected with the News Bureau of the General Electric Company.

Work on the world's largest hydroelectric generators, being built by the General Electric Company for installation at Boulder Dam, is in progress. The stator frame all-welded for one of the 82,500-kv-a. units, which will weigh more than 2,000,000 lb. apiece, is shown being assembled at Schenectady.

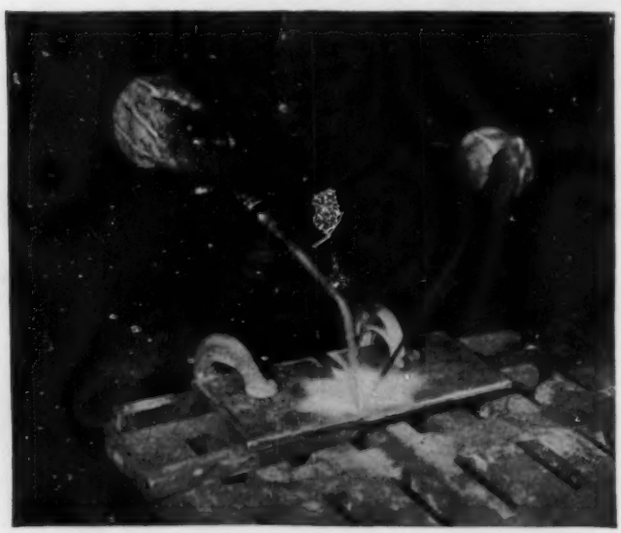
HOW TO WELD IT

Strong Welds for Strong Steel

By C. E. WESTIN

†Mr. Westin is member of the staff of the Technical Publicity Department, Electro Metallurgical Company.

INDUSTRY'S demands for materials of high strength and toughness have led to the development of alloy steels of many types. Where moderately priced steels having properties superior to plain carbon steels are required, Cromansil steels are being used to a large extent and fulfill every requirement. These easily manufactured open-hearth steels, containing chromium, manganese and silicon, extend the possibilities of alloy steel usage into many industries because of their relatively low cost. Some of these uses and also some of the physical properties of these steels have been described in an article published in the June 1933 issue of the JOURNAL OF THE AMERICAN WELDING SOCIETY.

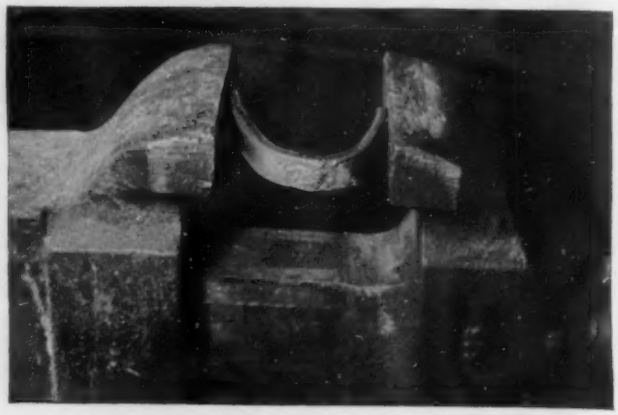


A Plate of Cromansil Steel from Which a Free-Bend Test Specimen Will Be Cut

The range of composition of Cromansil steels most widely employed at the present time contains from 0.4 to 0.6 per cent chromium, 1.1 to 1.4 per cent manganese and 0.7 to 0.9 per cent silicon, with the carbon content varying from less than 0.10 to 0.25 per cent.

In the as-rolled condition steel with this combination of alloys has better physical properties and higher strengths than any type of plain carbon steel. Strengths as high as 100,000 lb. per sq. in. in the as-rolled condition are obtainable. In addition, high fatigue limit, great ductility and high impact strength can be obtained in the as-rolled condition. A fatigue limit as high as 60 per cent of the ultimate strength can be procured.

Not a small factor in the performance of Cromansil steels is their ease of welding and the good strength of welded joints obtained. By the use of the correct rod and welding technique, strong, tough welds are made as easily as in ordinary steel.



The Specimen in Intermediate Stages of Test Shows No Evidence of Cracks

The welding procedure as well as the choice of welding rod depends on the thickness of the Cromansil sheet to be welded. For thin sheets $^1/_8$ in. and less in thickness, forehand welding, in which the flame points toward the unfinished part of the seam, is recommended. By this technique better control of the weld and greater speed are possible. On thin sheets and on plate up to $^1/_4$ in. in thickness high-test steel welding rod is recommended. The volume of the deposited rod is relatively small, and the alloys received from the melted base metal strengthen the steel from the rod sufficiently to produce weld metal strength equal to that of the base metal.

On steel plates $^3/_{16}$ in. and heavier the plate is beveled to a 70- or 90-deg. bevel as shown in Table 1, and in this case the backhand method of welding, in which the flame points toward the finished part of the seam, is advised. Control of the fusion in the bottom of the weld and along the sides of the scarf is easier to obtain with backhand welding, and also the hot gases pass back along the completed portion of the weld and retard the cooling, with consequent reduction in hardening of the weld and adjoining base metal.

In the following table are set down the conditions recommended for oxyacetylene welding of Cromansil steel:

Table 1

Plate Thickness, In.	Welding Rod Diam., In.	Welding Tip,* No.	Oxygen Pressure,* Lb. per Sq. In.	Bevel, Deg.
$^1/_{16}$	$^1/_{16}$	4	10	None
$^1/_8$	$^1/_8$	5	12	None
$^3/_{16}$	$^3/_{16}$	7	16	90
$^1/_4$	$^3/_{16}$	8	19	90
$^3/_8$	$^1/_4$	10	21	70
$^1/_2$	$^5/_{16}$	12	25	70
$^3/_4$ and over	$^5/_{16}$	15	30	70

* Welding tip sizes and oxygen pressures are for Oxweld Type W-1 blowpipes. For other blowpipes use equivalent tip sizes and pressures.

When welding material over $^1/_4$ in. thick, it is better to use an alloy rod of manganese-molybdenum steel because the volume of the weld metal is great enough so that the base metal melted into the weld would not supply enough of the alloys to give the desired strength to weld metal obtained from high-test steel welding rod.

Smaller sizes of welding tips are recommended for overhead and vertical welding and the extent of change will depend somewhat on the experience and skill of the operator in making these types of welds.

Overheating of the melted weld metal should be avoided, especially when the Cromansil steel contains 0.25 per cent carbon or more. If the welder has difficulty with overheating, a smaller tip than that recommended can be used; and for these higher carbon Cromansils, normalizing the weld at a temperature of 1650 deg. F. will give the best results.

Experience has shown that properly made welds will have even greater strength than 0.10 carbon Cromansil base metal, and the ductility will be such that in the free-bend test the per cent elongation in the outside fibers will be on the order of 30 per cent. In the 0.20 per cent carbon Cromansil steel the strength of the welds when made properly will be about the same as the base metal, and the elongation in the bend test about 20 per cent.

The Completed Test Illustrates the Fine Strength and Ductility of the Weld and Base Metal

FROM ABROAD

Recent Tests of Oxyacetylene Welding*

By **VICTOR A. AMODEO**

†Abstracted from article appearing in March 14, 1934 issue of "The Shipping World." Mr. Amodeo is Managing Director of The Acetylene & Welding Consulting Bureau, Ltd.

ALTHOUGH those who have been in touch with the progress made in the application of oxyacetylene welding in the last few years appreciate that it is not inferior to any other method of welding, knowledge of its possibilities is not frequently brought to the notice of engineers in this country. To remedy this to some extent and to demonstrate the efficiency of the process tests were recently made in the presence of the shipbuilding authorities—the Admiralty, Board of Trade, Lloyd's Register, the British Corporation Register and Bureau Veritas.

Just as in electric welding the quality of the deposited metal depends to a large extent on the type of electrode used, so in oxyacetylene welding is the type of filler rod of primary importance. The important difference is that in electric welding the rod must be protected from the effect of the atmosphere on the molten metal by some form of coating, whereas with oxyacetylene welding the flame itself provides an effective shield and the rod needs no coating. Nevertheless, it is important that a rod of the correct composition be used so that the deposited metal may have similar characteristics to metals to be joined, and in these tests a rod, known as carbon silicon manganese steel welding rod, produced by the British Oxygen Company, was employed. This is perhaps the first British rod so tested, although rods of Continental manufacture have been on the markets abroad for some time.

Requirements for Shipbuilding

It is part of the requirements of the Classification Societies that the metal deposited by any welding process should show characteristics not greatly different from those of the parent metal; and to enable the physical properties of the metal by this particular rod to be ascertained, test specimens were built up on the surface of mild steel plates. The specimens were then machined and tested for tensile strength, elongation, bending and Izod value. The average tensile strength obtained was 29.1 tons per sq. in.—a value well in excess of 26 tons per sq. in. as required by the specification and above the strength of shipbuilding steel having a tensile strength of 28 tons per sq. in. These test pieces gave an elongation of 20.1 per cent in eight times the diameter, which must be considered an excellent result, and which is well in excess of any requirement laid down for electric arc weld metal. Similarly deposited specimens were bent to much lesser included angles than the specification called for, and the Izod test values obtained from the average of several specimens, exceeded twice the 20 ft. per lb. value called for.

These results proved that the weld metal itself was satisfactory in all respects, and there remained to show that it could be so combined with the parent metal as to form a joint of the requisite strength. Several forms of connection commonly used in shipbuilding were tested, the most important being the ordinary butt joint. In this type of joint, the two plates have the edges chamfered to give an included angle of about 60° and are brought close enough together to have a gap of about $^1/_8$ in. between them. The weld is made by fusing the plate edges and at the same time depositing metal in the vee. The surface of the weld metal is machined flush with the plate so that the sectional area through both is exactly the same. The joint is made in one "run" as against a number of "runs" usually necessary in electric welding, and if the welding is carried out by the "Rightward" method a bead of weld metal is formed on the back of the vee. This latter feature will appeal to the shipbuilder, as the additional back run required to close the joint in electric welding is sometimes difficult, if not impossible to make, but unless it is applied, the value of the joint may be reduced by as much as 40 per cent.

Welding of Plates and Joints

Plates of $^1/_4$-in., $^1/_2$-in. and $^3/_4$-in. thickness were welded together, and the resulting joint tested in tension and by bending the plate in way of the weld. The average tensile strength of the $^1/_4$-in. specimens was 28.4 tons per sq. in., of the $^1/_2$-in. specimens 26.9 tons per sq. in. and of the $^3/_4$-in. specimens 27 tons per sq. in. The specification called for the strength of the welded

* EDITORS NOTE: Ton in this article refers to the long ton = 2240 lb.

plates to be not less than 26 tons per sq. in., so that this was exceeded by a comfortable margin, although it is only fair to point out that the average of the 1/2-in. specimens is reduced by the lower value of one in which the failure was due to lamination of the parent plate. Only one of twelve specimens failed to pass the bend test, and it is characteristic of butt welds made by the oxyacetylene process that the joint shows great ductility.

Although in riveted joints the plates must be overlapped, the overlapped *welded* joint is not favored. The Admiralty has expressed a preference for its use on account of greater ease of construction when it is adopted, but it is not economical when compared with the butt joint, and the bending moments induced in the plates as a result of the lack of symmetry render it theoretically less satisfactory from the strength point of view. The average value of four specimen tests under tensile load was 29.0 tons per sq. in., the specimens all failing in the plate clear of the joint.

This form of test is, of course, a test of the value of the fillet weld metal connecting the two plates, but it is designed to show the value when the load is applied at right angles to the weld. Further tests to find the value of the strength of fillets when the pull is in the direction of the length were made, and in these circumstances it is specified by Lloyd's Register that a fillet connecting two plates of 3/8-in. thickness should have a value of 4.12 tons per lin. in. The specimens tested showed an average value of 4.84 tons, thus giving a good margin over the requirements.

The Ductility of Metals

It is not unusual to find seams of plating in ship construction subject to stress in the direction of the joint, and in this case it is necessary to ensure that in a welded joint the characteristics of the weld metal and the parent metal are sufficiently similar to avoid the joint failing through the greater extension of one of them under load. To examine the relation between the ductility of the parent and that of the weld metal, specimens were made by welding two plates together and by subjecting the joint to tension in the line of the weld. The British Corporation, which includes this type of test in their requirements, specifies that the test piece must show no disturbance at the junction of the weld with the parent metal when stressed to 14 tons per sq. in. All specimens tested were entirely satisfactory at this stress, and right up to the point at which the specimen broke—about 30 tons per sq. in. Bend tests were made on plates welded at right angles to other plates and bent over, until parallel with each other without sign of failure, and finally vertical plates were welded on the upper and lower sides of a horizontal plate. These were then subjected to load to show at what stress the vertical plates could be pulled from the horizontal one. In three specimens out of four tested, the plates fractured before the weld failed, and in the fourth case the weld failed, but under a load corresponding to a stress in the plate of over 29 tons per sq. in.

It is not suggested that the successful completion of these tests solves all the problems involved in the application of oxyacetylene welding to shipbuilding, but they do show that the shipbuilder has at his command a process which, either alone or in conjunction with electric arc welding, may greatly assist him in the production of the all-welded ship. From the practical view-point the oxyacetylene process presents some important advantages, and the fact that, with the aid of the latest technique, the results can be such as satisfy the most stringent requirements, should encourage the shipbuilder to give it his serious consideration.

Prudential House in Warsaw (Poland)

By STEPHEN BRYLA

†Stephen Bryla, C. E. D. R. P., is Professor of The Technical Institute in Lwow (Poland).

THE Prudential House in Warsaw is the highest apartment house in Poland and the second highest house in Europe.

The architectural design shows the following arrangement of the building: in the middle of the front line, facing Napoleon Square, rises a tower of horizontal dimensions, 22 m. x 16.5 m. At the level of the 14th story the tower narrows down to 17 stories. As a whole, the tower consists of 19 stories out of which two are underground floors. The total height of the tower is 66.80 m. above the street level. There are two terraces, on the 14th and 17th floors of the tower.

On each side the tower ends in side wings 6 stories high each, i.e., 7 floors above the street level—the north wing facing Swietokrzyska Street and the south wing being adjacent to the walls of the neighboring houses. The length of the front line of each of these wings is 5.80 m.; they are connected by two diagonal wings, one of which is 12 m. wide and 15 m. high (4 stories) and the other 8 m. wide. The back area forms a courtyard connected by a passage with Swietokrzyska Street. A glass-covered wing with semi-arch-shaped walls is to be found immediately behind the first diagonal wing.

The wind pressure upon the tower walls is relatively high. Up to the height of 15 m. a 50 kg./m.^{2} wind pressure has been admitted, growing lineally with the height of the building and reaching 150 kg./m.^{2} at the height of 30 m. The last figure has been applied above 30 m. along the whole height of the tower. The result of the wind pressure is the growth of load, especially in the

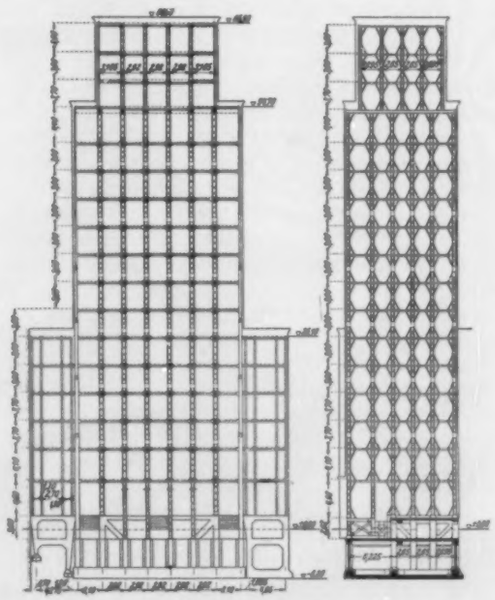


Fig. 1—Elevation Plan of Building

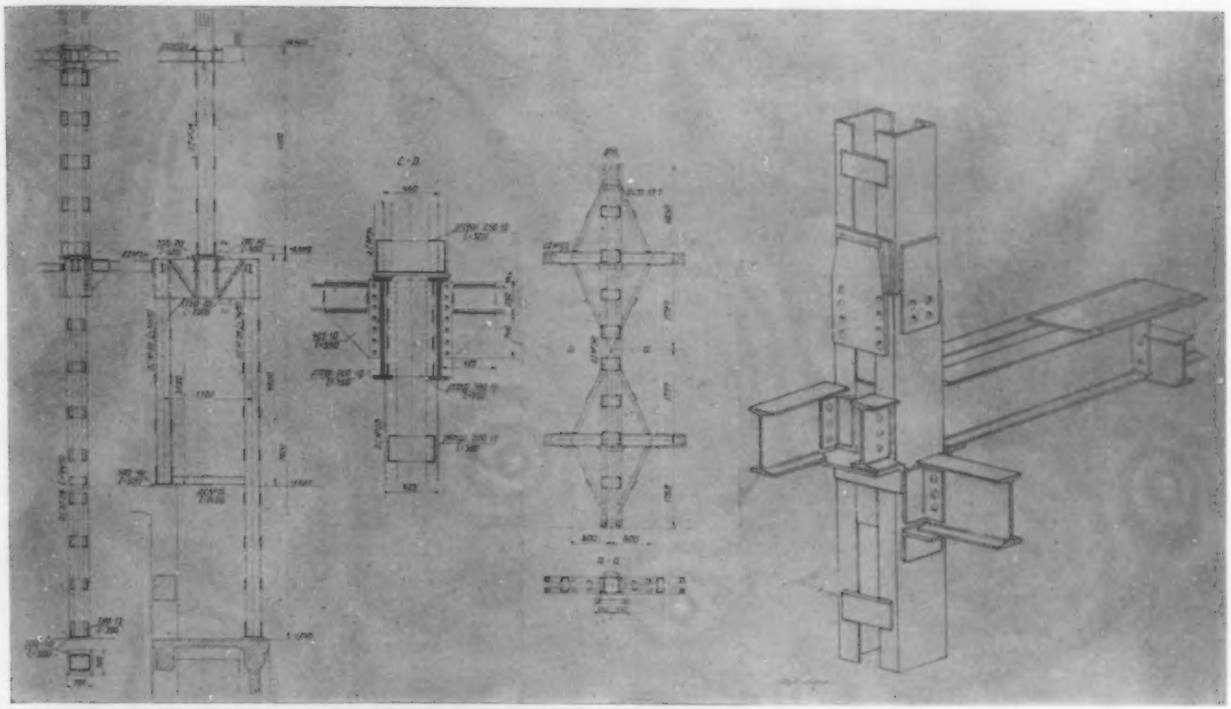


Fig. 2 Fig. 3 Fig. 4

EW direction, vertical to the building front. This additional load reached 130 tons in some pillars. The wind pressure has been also taken into consideration in the NS direction parallel to the building front, although its influence, owing to a smaller surface subject to the wind pressure and to a larger base, is considerably smaller. The total stress in a pillar, resulting from vertical load and from wind pressure, amounts to 313 tons.

The steel frame consists of two parts divided by an expansion joint. These parts are the tower and the remaining part of the building. These two parts were so different in design and construction that two different contractors could be easily entrusted with the execution of the steel frame.

At the height of the 14th story the tower narrows down, vertical and side stanchions recede and the latter change their axes. The side stanchions had, therefore, to be supported by strong girders consisting of two I-beams NP.50. The wind bracings had to be executed in a different way; a horizontal grate made of I-beams NP.24 and of flat iron has been fixed around the outline of the tower.

Stanchions placed on the NS lines of the tower consist generally of I-beams fixed in a distance of 440 mm. and connected by means of welded sheet-iron straps. The profiles of the iron at the lower end of the stanchions most heavily loaded amount to NP.47.5. The bases of the lower stanchions are fixed on bearing plates 50 mm. thick, 900 mm. long and 900 mm. wide. (See Fig.2.)

Four front stanchions are placed in pairs. A recess has been made in this part of the front wall and the entrance is adorned with a portico. Under each upper column there are, therefore, two lower columns connected by a welded twin web-plate supporting the upper columns loaded with 165 tons. These stanchions are connected in the middle of the height of the longer one in order to reduce its free length. Girders supporting the walls consist of two I-beams NP.20 to NP.30.

The steel frame of the side walls acts at the same time as vertical wind bracing. This was greatly facilitated by the fact that the distances between the stanchions had to be rather small (265–285 mm.). The stanchions are made of two I-beams. They do not represent, however, the assembly element which has a shape of a doubled cross and consists of a part of the stanchion going through the lower, middle and upper floors, as well as of a part of the girders enclosed between two centers of the distance between two stanchions and of adequate angle bracings. (See Fig. 3.)

Similar elements are to be found in the upper part of the tower. Their construction, however, is different; they consist of stanchions two stories high. The stanchions are made below of I-beams and above of channels; the girders are also made either of I-beams or of channels, corner bracings are made of two angles forming a closed section and welded to the stanchion and to the girder.

In the lower part of the building the stanchions consist of two channels (Fig. 4) stiffened with cover plates. Girders are chiefly continuous. They are led through the stanchions between the channels, resting on angles and on cover plates welded to the channels. Girders are mostly placed in pairs, in view of the small height and small admissible bending stress of the ceiling. Girders supporting the outside walls are also placed in pairs in order to provide a convenient support for the walls. In some stanchions the girders had to be placed outside the stanchions. This has been effected by means of angles welded to the stanchions. Vertical angles were applied in order to fix the web, and horizontal angles were applied to fix the flange.

Cantilevered stanchions on which girders are resting eccentrically are also to be found in this frame, especially on the boundary line. Such a construction is executed in the following way: an I-beam which supports the girder is led through the ceiling. (See Fig. 5.) The I-beams are led through holes cut in the web of the stanchion by means of oxyacetylene flame and are supported by an angle which is welded to the stanchion. (See Fig. 6.) The girder has also, in its point of support, a rib made of an I-beam and fixed with two angles welded to the stanchion.

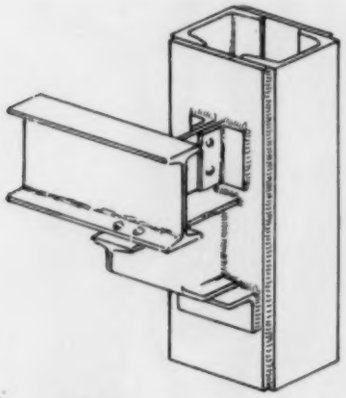


Fig. 5

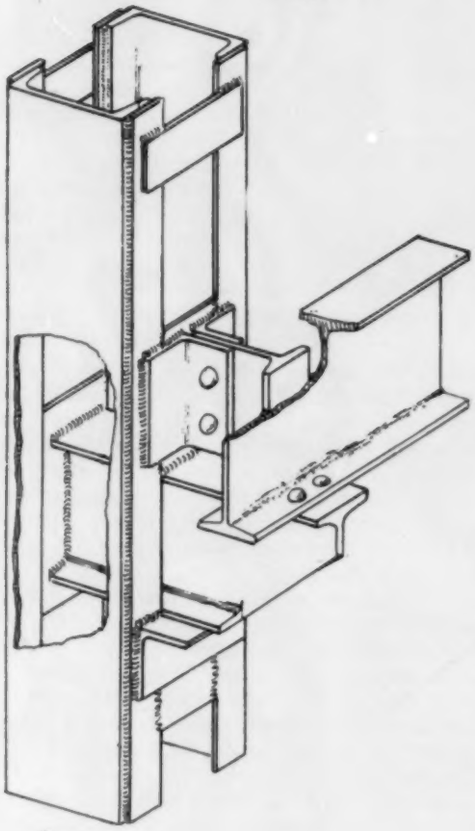


Fig. 6

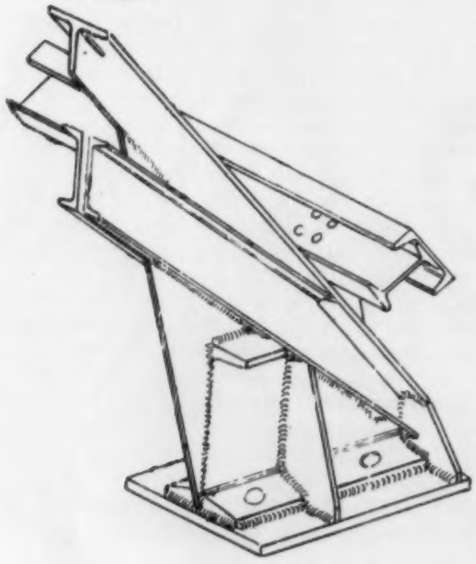


Fig. 7

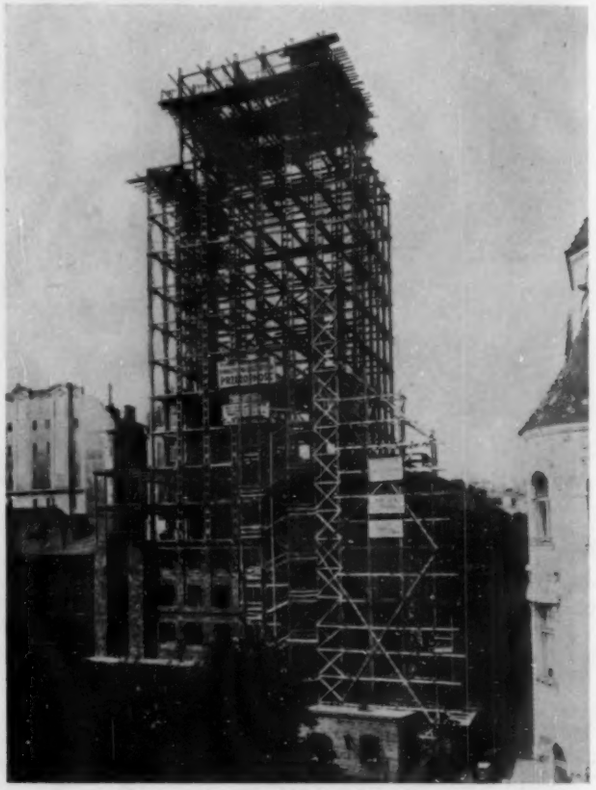


Fig. 8

In places where girders are fixed the stanchions are provided with short angles, in view of the fact that all girders connected with the stanchion are supported by horizontal angles and stiffened from both sides with vertical angles. These angles have been welded to the stanchions in the workshop and are provided with holes for assembly rivets.

The butt joints in stanchions are longitudinal. The cover plates have been welded to the upper (smaller) girder and bearing plates have been welded to several girders in order to equalize their height. During the assembly the cover plates have been riveted to the upper part of the stanchions. Stanchion-bases are made of thick bearing plates. Stiffening trapezoidal plates (like those in the tower-stanchions) have not been applied. All stanchions have been placed on lead bearings consisting of 3–5 sheets of lead, 4 mm. thick.

The detail of the support of the welded roof is shown in Fig. 7.

The total weight of the steel frame is 1175 tons, out of which the weight of the tower is 500 tons, the weight of the 5-story building is 605 tons and the weight of the roof over the main hall is 10 tons. When compared with a riveted construction the economy in weight is 12%.

Figures 8 and 9 represent the construction and the finished building.

Bipedal and tripedal scaffolds together with a hand hoist have been used for the assembly of the lower part of the steel frame. The upper part has been assembled with aid of electric derricks. Light elements, e.g., parts of staircases, lifts, etc., have been lifted by means of ordinary single hoists.

During the assembly of the 6-story part a temporary stiffening construction made of wooden beams has been erected in order to avoid shocks and deformations. This construction has been removed during the execution of masonry walls.

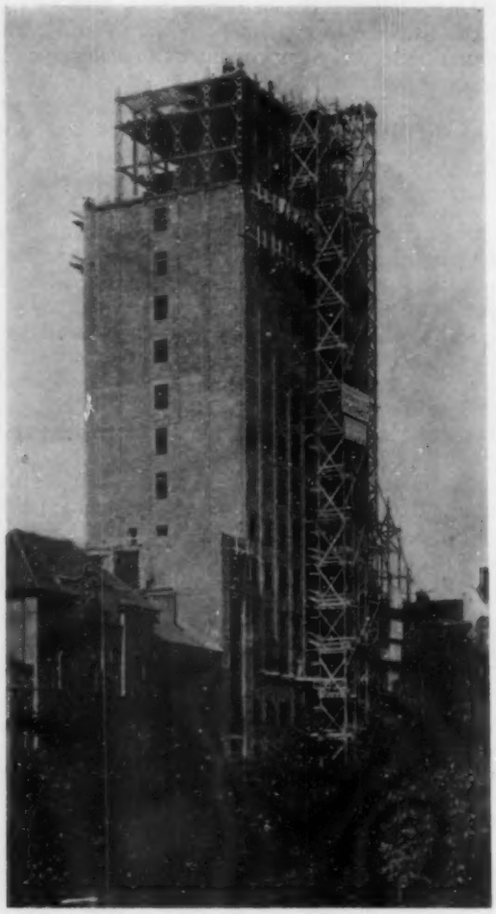


Fig. 9

A similar stiffening construction has been applied in the tower, viz., in the central row of stanchions. Wooden diagonals have been applied in form of oblique crosses going through several floors.

During the erection of the building several changes occurred in the design and caused a series of changes in the construction of the building. The more important changes were: the addition of the 16th story and the introduction of a passage in the ground floor between the tower and the corner staircase. In this place a very important wind bracing has been placed. It had to be removed, and subsequently other structural elements: in the first place the adjoining stanchion had to be adequately strengthened. Parts to be removed have been cut out easily with aid of oxyacetylene flame. As regards elements which needed strengthening, some were still in the workshop and some were on the building premises; the former have been strengthened with aid of acetylene welding, the latter with aid of electric welding.

The strengthening of the frame, caused by the addition of the 16th floor, has been effected in several stanchions and girders supporting the upper stanchions and consisting of two joined I-beams. The strengthening of these girders has been very difficult, the whole of workshop-construction being ready. The height of the girders could not be increased by addition of cover plates and a new girder could not be added, this being unnecessary for such a slight strengthening. For these reasons it has been decided to weld additional flat irons to the flanges of the girders and to stiffen the webs of the girders by means of ribs and of flat irons welded to these girders. All these changes have proved the great advantages of welding and cutting by means of acetylene as well as by means of electricity.

APPENDIX A

Comments on New Polish Regulations Concerning Steel-Welded Constructions

EDITOR'S NOTE: Publication of the Polish regulations is contemplated in an early issue of the Journal.

The first Polish regulations concerning steel-welded constructions were issued in 1928. Thus, Poland was the first country in which official regulations were issued, the German regulations being issued only in 1930[1].

In 1930 were issued regulations concerning welded steel buildings. New regulations have been actually approved; their characteristics are given below:

The new Polish regulations differ considerably from the 1928 regulations and from regulations issued in other countries, e.g., in Germany. They are more severe as regards requirements put to the contractors and at the same time more liberal as regards the constructors. They offer big possibilities for welded constructions, giving at the same time full guarantee of their stability and high quality.

Among other features we find there high admissible stresses for tension, compression and bending, as well as for shearing in welds smaller than 12 x 12 mm. Welds of such dimensions are most frequent in welded constructions.

A most characteristic feature is also the disposition of admissible stresses depending upon the thickness of welds, whereby admissible stresses for thick welds are much higher not only than the German but also than the American and Belgian admissible stresses. This results in a slight difficulty in calculation. On the other hand, it enables a good utilization of welds and maintenance of the same security in each particular weld.

The new Polish regulations are much more elastic than the German regulations because they allow the use of welding rods and the employment of welders even in such cases when the breaking stresses obtained are lower (up to 15%) than those required by the regulations, which, as mentioned already, are relatively high. In such cases the admissible stresses are, of course, accordingly reduced.

The elasticity of the regulations upward is even more important. If higher strength is obtained, the admissible stress may be also increased. This is an evident premium for good welders and good welding rods. In order to avoid uneven work and to assure a sufficient control of same, the regulations introduce a Welding Diary in which all data concerning the execution of each particular weld in the shop as well as on the building premises should be entered. For the same purpose the regulations introduce a periodical control of the welder's skill. Tests which have to be executed by the welder are based on the same principle as the previous tests but their form is more simple. Tests for shearing of filler in normal shear instead of fillets in parallel shear are decisive, which permits the use of breaking stresses twice as small.

Admissible Stresses

The admissible stresses for compression, bending and breaking are all equal, viz., 1000 kg./cm.^{2}

We will consider now the shearing stress. Small welds

[1] JOURNAL OF THE AMERICAN WELDING SOCIETY, Jan. 1933.

subject to shearing are undoubtedly relatively stronger than large welds and this for following reasons: Small welds consist of one layer of welding metal, whereas large welds consist of several layers depending upon the thickness of the weld and the diameter of the welding rod.

Although the preceding layer has always to be well cleaned before applying the next layer, the connection is not the ideal one. Also the inner tensions increase simultaneously with the weld's thickness. Finally the moment of eccentricity of the force toward the weld's center of gravity acts here. Such a moment is higher for thicker welds. It is also very important that the depth of penetration of a weld amounts to 1–2 mm. for every thickness of the weld. The theoretical shearing surface of the weld is thus increased by 1–2 mm., whereby the weld's strength increases also. The relation between the depth of the electrode's penetration and the theoretical shearing section is higher for small welds than for thick welds, e.g., at a penetration of 2 mm. the section of a 4 x 4-mm. weld is increased by 70%, whereas the section of a 20 x 20-mm. weld is increased only by 14%. The influence of the theoretical increase of the section owing to the penetration of the welding rod and, thus, of the increase of the weld's strength is much bigger in small welds than in thick welds.

Already the Polish regulations of 1928 have taken this point into consideration by introducing the increase of admissible stresses (on the unit of sheared surface) according to a straight line. The German and American regulations have gone another way; they introduced a constant admissible stress (on a unit of surface) independent from the weld's thickness. This regulation, very convenient for calculation purposes, is not very practical.

In Polish regulations the admissible stress for each particular weld has been calculated on the basis of a series of tests executed by the author, admitting 1200 kg./cm.^{2} as basic admissible stress of structural material. For other stresses these figures should be multiplicated by the coefficient $k/1200$. Thus, the admissible stresses for welds in different constructions have been expressed by one short formula. As regards welded structures the above rule concerns the basic stresses of 1400 or 1600 kg./cm.^{2} As regards bridges, these rules can be easily adapted to bridge constructions.

The differences between admissible shearing stresses in Polish and German regulations are, therefore, considerable. For the 12 x 12-mm. weld the figures in both regulations are nearly equal. For smaller welds the admissible stresses are more than 40% higher in Poland than in Germany (for a 5 x 5-mm. weld); for thicker welds a decrease reaching 17.5% is visible in Polish regulations.

These figures are very important because in consequence they require the use of possible small welds, as being more economical when compared with large welds.

The paragraph allowing a further increase of admissible shearing stresses is very important. Such an increase may take place only when tests executed according to this paragraph give adequate results. It is a premium for good welding rods and good welders.

Tests of Welding Rods

The regulations introduce tests for breaking, bending and shearing of welds with two purposes: (*a*) in order to test welding rods and to allow the use of successfully tested welding rods in welded construction; (*b*) in order to test and control the welder.

The tests of welding rods have been changed as compared with the previous regulations. The required breaking stress has been increased to 3700 kg./cm.^{2} as compared to the old Polish regulations (2960 kg./cm.^{2}) and to the German regulations (3000 kg./cm.^{2}), which is wholly justified by the improvement of welding rods and welding methods.

Tests for shearing of fillet welds, introduced for the first time by the Polish regulations of 1928 and adapted with modifications by the Germans, have been now slightly altered. Tests for shearing of slot welds are left out. Instead of it tests of fillets in normal shear have been introduced (in order to facilitate the control on the building premises).

The Polish regulations have also introduced the following innovation: The Ministry of the Interior may allow the permanent use of welding rods successfully tested, without submitting them every time to tests. This innovation was very desirable because it enabled the choice of welding rods during the work without submitting them to tests. In Poland coated welding rods are chiefly used.

As a proof of the liberality of the Polish regulations there is cited the paragraph according to which the execution of a construction is allowed even if the results of tests are 15% lower than the results required. Evidently the admissible stresses should be reduced accordingly. Thus, the introduction of young firms is rendered possible and the development of welding technique is facilitated, reliable firms being at the same time favorized.

Control of Welders and Welding Diary

Modern methods allow a control of every weld better than of any other structural element. These methods are evidently not needed for practical use and, besides, are expensive and inconvenient. For this reason the regulations introduce another method, viz., a general control of welders every 6 months and every time when the welder changes his job, if in the meantime he dropped welding for more than a month. The welder must execute tests for shearing, bending and breaking of fillets in normal shear.

In order to facilitate the control and to discern which welder is responsible for which weld, a special Welding Diary has been introduced. The Welding Diary is twofold: the Welding Shop Diary and the Field Diary.

The Welding Shop Diary may be kept either for one particular building or for all of the welding executed by the given shop. The second method is adopted as a rule, especially when small work is executed. In case of a larger job it is wiser to keep a special diary in order to present it upon request to the building authorities without making special copies.

The Field Diary has a similar aim with regard to the work executed on the building site. Although the control of welding in the shop has existed before these regulations were issued, the control on the building site was quite neglected, taking into consideration that often everybody was "too busy" to enter all necessary data and that the execution on the building site is, of course, not so good as in the shop.

The general plan of the structure together with statical calculations should be found always on the building premises. However, it is not required that detailed plans should be executed before starting work. Plans are often executed in succession. Some secondary construction is often executed direct on the building without any detailed plans. The execution of such plans would often delay the work and the term of completion of the building.

New Polish regulations are severe and at the same time elastic and liberal. They require a thorough control and set high standards to the welding industry.

Welded Steel Engine Bed on C., B. & Q. High-Speed Streamlined "Zephyr"

By ROBERT W. WOLCOTT

†Mr. Wolcott is President of the Lukens Steel Company.

ON THE Chicago, Burlington & Quincy Railroad Company's new high-speed streamlined passenger train, the "Zephyr," the engine bed (or chassis of the motive power unit) is of welded construction, fabricated from Lukens Cromansil steel, a recently developed, high-strength steel. This application is believed to be the first instance of the use of a welded steel engine bed on a motive power unit employed in mainline railway service in America.

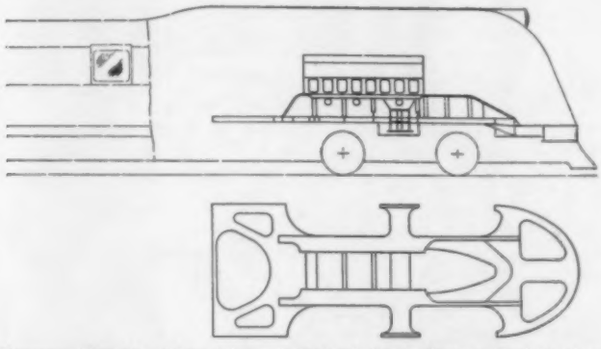
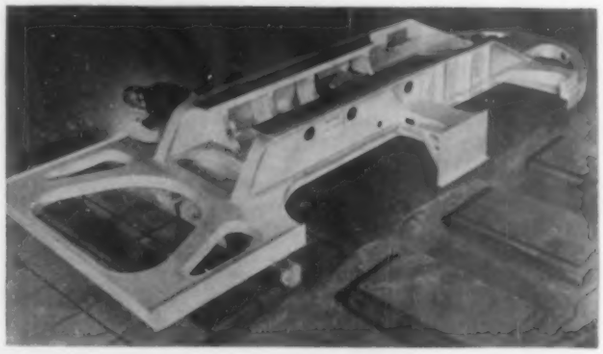


Diagram Showing Plan View of Welded Steel Engine Bed Used on "Zephyr" High-Speed Streamlined Train of the Chicago, Burlington & Quincy Railroad, with Elevation Sketch Showing Location on the Train of the Welded Steel Engine Bed and Welded Steel Crankcase in the Winton Full Diesel Engine Which Powers the Train

The welded steel underframe supports a load of approximately 60,000 lb., consisting of the 600 hp., Winton full Diesel engine and generator which power the train and the forward half of the power car. This 30-ton dead load imposes severe impact stresses on its supporting bed under the operating conditions encountered in service. The stresses are of a fatigue nature, since they are repeated many times per mile.

Because of the infinite variety of types of load to which the structure is subjected in service, analysis of the loads is highly indeterminate. Rail joints, switches and crossovers cause vertical impact. Acceleration and deceleration result in horizontal stresses of variable extent. Movement around curves at speed produces lateral stresses. Combinations of the various forms of stress can occur simultaneously. The requirements of service are further complicated by the necessity of minimizing weight. Naturally, the working stresses are high.

The design of the engine bed was developed by Lukenweld, Inc., division of Lukens Steel Company, Coatesville, Pa., in cooperation with the Edward G. Budd



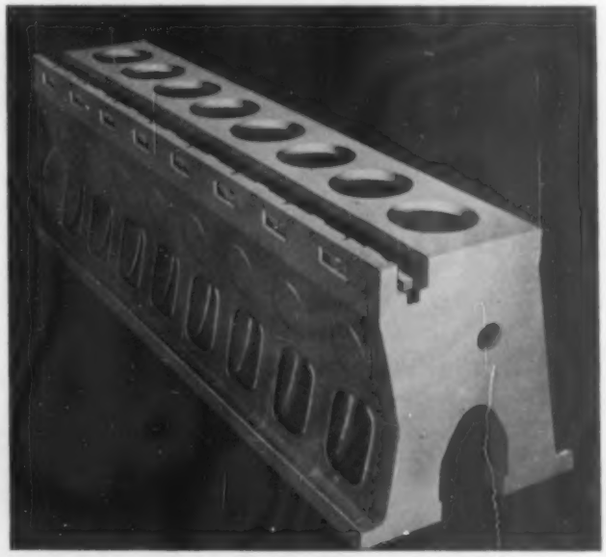
Electricity and Alloy Steel Make a "Bed" for the High-Speed Streamlined "Zephyr"

Completing the bed which supports the power car on the "Zephyr." It was fabricated from steel plates of a new high-strength alloy steel known as Cromansil. Two hundred and four separate steel plates were used and they were cut to shape by oxyacetylene flame then formed as required in powerful presses, and finally made into the one-piece bed by means of the electric arc. The completed engine bed weighs only 3 tons, and supports 30 tons of lead.

Manufacturing Company, builder of the "Zephyr," and the Railroad Company. In developing the design, particular attention was given to the elimination of rectilinear elements which would involve undesirable concentrations of stress. Angles, channels and "picture-frame" correlations were avoided because they would result in severe changes in contour which, in turn, would be incipient points of failure.

It will be noted that the engine bed design utilizes extremely moderate changes in contour not only to avoid concentrations of stress but also to introduce a high degree of redundancy. The mutual interaction of adjacent members is an important element in the functioning of the structure as a single unit rather than as a connected assembly of individual members.

The engine bed is 25 ft. $3^1/_2$ in. long, 8 ft. 8 in. wide and fabricated from $^5/_{16}$-in. plates of Lukens Cromansil steel. It has a high ratio of load-carrying capacity to weight of metal employed, since it weighs only 6060 lb. and supports the 60,000-lb. load of engine, generator and forward half of the power car. It forms the bed of the front half of the first car of the train and is joined



Welded Steel Crankcase on Winton Diesel Powering the High-Speed, Streamlined "Zephyr" Train

at the rear to the stainless steel structure forming the balance of the car.

In addition to the engine bed, the crankcase of the Winton full Diesel engine powering the train is also of welded construction, fabricated by Lukenweld, Inc., from Lukens Cromansil steel. The engine is two-cycle, 600 hp., with eight cylinders in line, direct connected to the generator. The complete engine, without generator and auxiliaries, weighs about 22 lb. per hp., which low ratio of weight to hp. is largely the result of efficient design and fabrication in welded steel construction.

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